Anthocerotophyta, Bryophyta and Marchantiophyta (Plant Divisions)

Jackelyn Langer

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Table of Contents

Chapter- 1

Hornwort

Hornwort
Temporal range: 90–0 Ma
Upper Cretaceous to recent

Phaeoceros laevis (L.) Prosk.

Scientific classification

Kingdom: Plantae

Division: **Anthocerotophyta**
Stotler & Stotl.-Crand.

Classes & Orders

Leiosporocerotopsida

- Leiosporocerotales

Anthocerotopsida

- Anthocerotales
- Dendrocerotales
- Notothyladales
- Phymatocerotales

Synonyms

Anthocerotae

Hornworts are a group of bryophytes, or non-vascular plants, comprising the division **Anthocerotophyta**. The common name refers to the elongated horn-like structure, which is the sporophyte. The flattened, green plant body of a hornwort is the gametophyte plant.

Hornworts may be found worldwide, though they tend to grow only in places that are damp or humid. Some species grow in large numbers as tiny weeds in the soil of gardens and cultivated fields. Large tropical and sub-tropical species of *Dendroceros* may be found growing on the bark of trees.

Description

The plant body of a hornwort is a haploid gametophyte stage. This stage usually grows as a thin rosette or ribbon-like thallus between one and five centimeters in diameter. Each cell of the thallus usually contains just one chloroplast per cell. In most species, this chloroplast is fused with other organelles to form a large pyrenoid that both manufactures and stores food. This particular feature is very unusual in land plants, but is common among algae.

Many hornworts develop internal mucilage-filled cavities when groups of cells break down. These cavities are invaded by photosynthetic cyanobacteria, especially species of *Nostoc*. Such colonies of bacteria growing inside the thallus give the hornwort a distinctive blue-green color. There may also be small *slime pores* on the underside of the thallus. These pores superficially resemble the stomata of other plants.

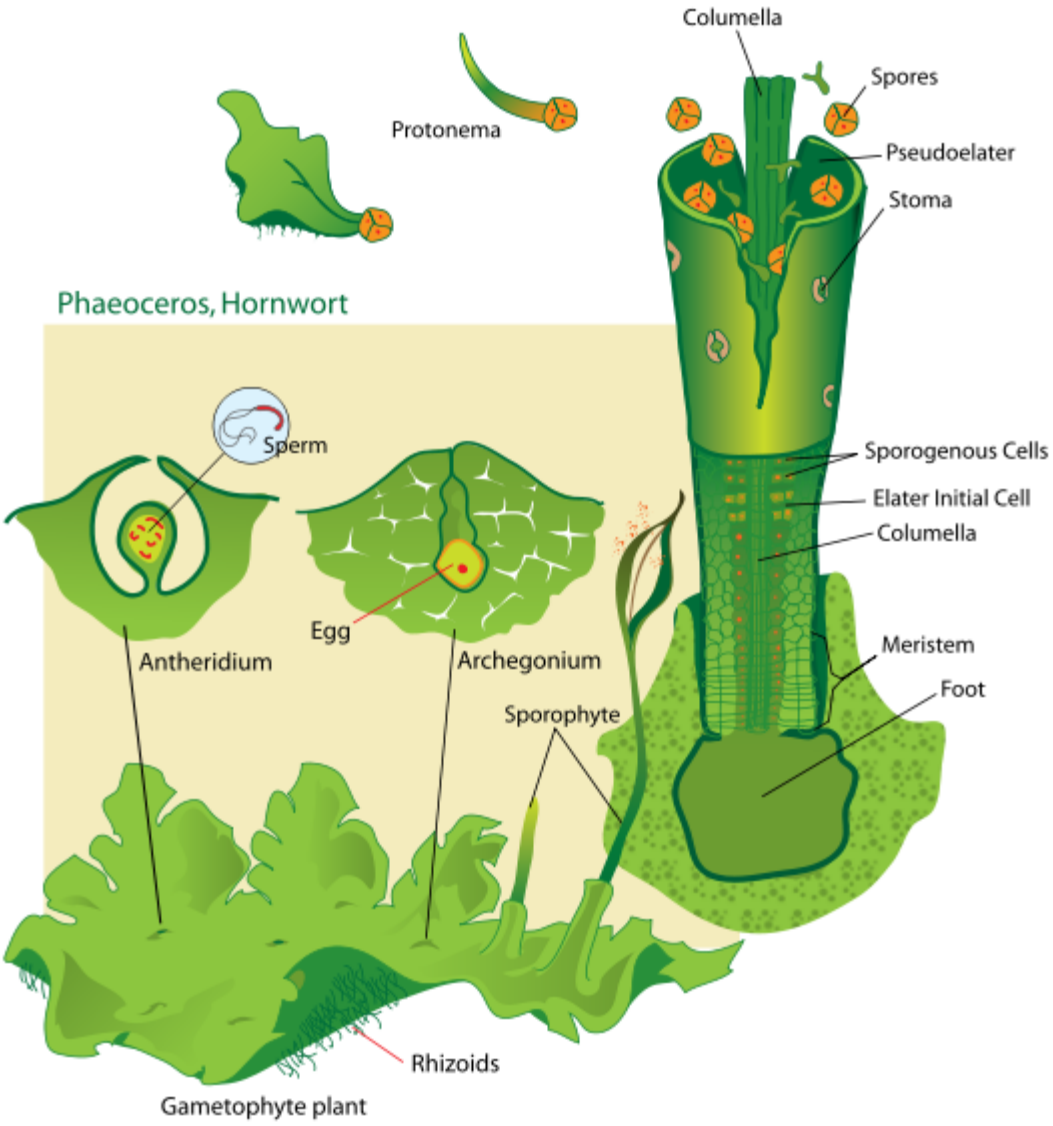
The horn-shaped sporophyte grows from an archegonium embedded deep in the gametophyte. The sporophyte of a hornwort is unusual in that it grows from a meristem near its base, instead of from its tip the way other plants do. Unlike liverworts, most hornworts have true stomata on their sporophyte as mosses do. The exceptions are the genera *Notothylas* and *Megaceros*, which do not have stomata.

When the sporophyte is mature, it has a multicellular outer layer, a central rod-like columella running up the center, and a layer of tissue in between that produces spores and pseudo-elaters. The pseudo-elaters are multi-cellular, unlike the elaters of liverworts. They have helical thickenings that change shape in response to drying out; they twist and thereby help to disperse the spores. Hornwort spores are relatively large for bryophytes, measuring between 30 and 80 μm in diameter or more. The spores are polar, usually with a distinctive Y-shaped tri-radiate ridge on the proximal surface, and with a distal surface ornamented with bumps or spines.

Life cycle

The life of a hornwort starts from a haploid spore. In most species, there is a single cell inside the spore, and a slender extension of this cell called the *germ tube* germinates from

the proximal side of the spore. The tip of the germ tube divides to form an octant of cells, and the first rhizoid grows as an extension of the original germ cell. The tip continues to divide new cells, which produces a thalloid protonema. By contrast, species of the family Dendrocerotaceae may begin dividing within the spore, becoming multicellular and even photosynthetic before the spore germinates. In either case, the protonema is a transitory stage in the life of a hornwort.



Life cycle of a typical hornwort *Phaeoceros*

From the protonema grows the adult gametophyte, which is the persistent and independent stage in the life cycle. This stage usually grows as a thin rosette or ribbon-like thallus between one and five centimeters in diameter, and several layers of cells in

thickness. It is green or yellow-green from the chlorophyll in its cells, or bluish-green when colonies of cyanobacteria grow inside the plant.

When the gametophyte has grown to its adult size, it produces the sex organs of the hornwort. Most plants are monoicous, with both sex organs on the same plant, but some plants (even within the same species) are dioicous, with separate male and female gametophytes. The female organs are known as archegonia (singular archegonium) and the male organs are known as antheridia (singular antheridium). Both kinds of organs develop just below the surface of the plant and are only later exposed by disintegration of the overlying cells.

The biflagellate sperm must swim from the antheridia, or else be splashed to the archegonia. When this happens, the sperm and egg cell fuse to form a zygote, the cell from which the sporophyte stage of the life cycle will develop. Unlike all other bryophytes, the first cell division of the zygote is longitudinal. Further divisions produce three basic regions of the sporophyte.

At the bottom of the sporophyte (closest to the interior of the gametophyte), is a foot. This is a globular group of cells that receives nutrients from the parent gametophyte, on which the sporophyte will spend its entire existence. In the middle of the sporophyte (just above the foot), is a meristem that will continue to divide and produce new cells for the third region. This third region is the capsule. Both the central and surface cells of the capsule are sterile, but between them is a layer of cells that will divide to produce pseudo-elaters and spores. These are released from the capsule when it splits lengthwise from the tip.

Evolutionary history

While the fossil record of crown group hornworts only begins in the upper Cretaceous, the lower Devonian *Horneophyton* may represent a stem group to the clade, as it possesses a sporangium with central columella not attached at the roof. However, the same form of columella is also characteristic of basal moss groups, such as the Sphagnopsida and Andreaeopsida, and has been interpreted as a character common to all early land plants with stomata.

Classification

The hornwort *Dendroceros crispus* growing on the bark of a tree

Hornworts were traditionally considered a class within the division Bryophyta (bryophytes). However, it now appears that this former division is paraphyletic, so the hornworts are now given their own division, **Anthocerotophyta**. The division Bryophyta is now restricted to include only mosses.

Traditionally, there is a single class of hornworts, called **Anthocerotopsida**, or older **Anthocerotae**. More recently, a second class Leiosporocertotopsida has been segregated for the singularly unusual species *Leiosporoceros dussii*. All other hornworts remain in the class Anthocerotopsida. These two classes are divided further into five orders, each containing a single family.

Among land plants, hornworts appear to be one of the oldest surviving lineages; cladistic analysis implies that the group originated prior to the Devonian, around the same time as the mosses and liverworts. There are only about 100 species known, but new species are still being discovered. The number and names of genera are a current matter of investigation, and several competing classification schemes have been published since 1988.

Chapter- 2

Anthoceros Agrestis and Anthoceros

Anthoceros agrestis

Anthoceros agrestis

Anthoceros agrestis in Schwäbisch-Fränkische Waldberge, Deutschland.

Scientific classification	
Kingdom:	Plantae
Division:	Anthocerotophyta
Class:	Anthocerotopsida
Order:	Anthocerotales
Family:	Anthocerotaceae
Genus:	*Anthoceros*
Species:	***A. agrestis***

Binomial name

Anthoceros agrestis
(Paton) Damsholt

Synonyms

- *Anthoceros multifidus* auct. non. L.
- *Anthoceros nagasakiensis* Steph.
- *Anthoceros punctatus* auct. non L.
- *Anthoceros punctatus L. var. cavernosus* (Nees) Gottsche Lindenb. & Nees
- *Aspiromitus agrestis* (Paton) Schljakov
- *Aspiromitus cavernosus* (Nees) Schljakov
- *Aspiromitus punctatus* (L.) Schljakov var. agrestis (Paton) R.M. Schust.
- *A. crispulus* non (Mont.) Douin
- *Anthoceros constans* Lindb.
- *Anthoceros husnotii* Steph.
- *Anthoceros longicapsulus* Steph.
- *Anthoceros multilobulus* Lindb.
- *Anthoceros punctatus var. cavernosus* (Nees) Gottsche Lindenb. & Nees
- *Aspiromitus punctatus agrestis agrestis* (Paton) R. M. Schust.

Anthoceros agrestis, commonly called **Field Hornwort**, is a lichen of the anthoceros genus. It has complicated taxonomies.

Taxonomy

A specimen of *anthoceros agrestis* in Schwäbisch-Fränkische Waldberge, Deutschland

This species of anthoceros is known for having acids like cinnamic acid 4-hydroxylase (EC 1.14.13.11), a cytochrome P450-dependent hydroxylase. Cinnamic acid 4-hydroxylase (C4H; EC 1.14.13.11) is one of the first known plant cytochrome P450 monooxygenases (Russell and Conn 1967, Russell 1971) and also one of the best-characterized cytochrome P450 hydroxylases from higher plants (Werck-Reichhardt 1995).

Production of rosmarinic acid and a new rosmarinic acid 3'-O-beta-D-glucoside in suspension cultures of this hornwort was also discovered recently.

Anthocerodiazonin, an alkaloid, was isolated from in vitro cultures of the species. Also, six glutamic acid amides, N-(4-hydroxybenzoyl)-glutamic acid, N-(3,4-dihydroxybenzoyl)-glutamic acid, N-(4-hydroxy-3-methoxybenzoyl)-glutamic acid, (E)-N-(isoferuloyl)-glutamic acid, (Z)-N-(isoferuloyl)-glutamic acid and (Z)-N-(p-coumaroyl)-glutamic acid were obtained as natural products.

Anthoceros

Anthoceros

Anthoceros agrestis

Scientific classification	
Kingdom:	Plantae
Division:	Anthocerotophyta
Class:	Anthocerotopsida
Order:	Anthocerotales
Family:	Anthocerotaceae
Genus:	***Anthoceros***

Anthoceros is a genus of hornworts in the family Anthocerotaceae. The genus is global in its distribution. Its name means 'flower horn', and refers to the characteristic horn-shaped sporophytes that all hornworts produce. The dark color of the spores is the easiest way to distinguish *Anthoceros* from the related genus *Phaeoceros*, which produces spores that are yellow.

The genus is distinguished by having spores that are dark brown to black, a relatively frilly thallus when compared to *Phaeoceros*, and larger and more internal cavities than *Phaeoceros*.

Species

Species include:

- *Anthoceros agrestis*
- *Anthoceros neesii*

Chapter- 3

Dendroceros and Folioceros

Dendroceros

Dendroceros

Dendroceros sp. Nees
growing on the bark of a tree

Scientific classification	
Kingdom:	Plantae
Division:	Anthocerotophyta
Class:	Anthocerotopsida
Order:	Dendrocerotales
Family:	Dendrocerotaceae
Genus:	***Dendroceros*** Nees in Gottsche, Lindenb. & Nees

Dendroceros is a genus of hornworts in the family Dendrocerotaceae. The genus contains about 51 species native to tropical and sub-tropical regions of the world.

Description

The gametophyte is yellowish-green and usually less than one-half cm wide. The thallus branches in a bifurcating pattern. In the subgenus *Apoceros*, there are cavities in the central strand of the thallus. The edges of the thallus are only a single layer of cells thick and have an undulating margin. It is common to find symbiotic colonies of blue-green bacteria (usually *Nostoc*) growing among the cells. Under a microscope, the epidermal cells have trigones.

The sporophyte is erect when mature, growing up to 5 cm tall. Like other hornworts, its surface has stomata. The interior of the sporophyte differentiates into a central column and a surrounding mass of spores and elater cells, with a distinct spiral. The spores are both green and relatively large with an ornamented surface.

Habitat

Dendroceros grows on humid ground, rocky outcrops, and on the sides of trees. Its name literally means "tree horn".

Folioceros

Folioceros	
Scientific classification	
Kingdom:	Plantae
Division:	Anthocerotophyta
Class:	Anthocerotopsida
Order:	Anthocerotales
Family:	Anthocerotaceae
Genus:	***Folioceros*** Bharad.
Species	

Folioceros appendiculatus
Folioceros assamicus
Folioceros dixitianus
Folioceros fuciformis
Folioceros glandulosus
Folioceros indicus
Folioceros kashyapii
Folioceros mamillisporus
Folioceros mangaloreus

Folioceros paliformis
Folioceros physocladus
Folioceros satpurensis
Folioceros spinisporus
Folioceros udarii
Folioceros vesiculosus

Folioceros is a genus of hornworts in the family Anthocerotaceae. The genus is common locally in the tropical and subtropical regions of Asia, growing on moist rocks, in fallow fields, and near waterfalls. It has a yellow-green gametophyte thallus that is crispy and translucent, with short branchings that are almost pinnate. Plants are usually less than a centimeter wide and 3 centimeters long. They may be monoicous or dioicous.

The genus *Folioceros* was formally diagnosed by the botanist D. C. Bharadwaj and based on the type species *F. assamicus*. Some features that he cited as distinguishing the genus were:

- Pseudoelaters less than 7 um wide and more than 300 um long.
- Spore ornamentation that is spinose or baculate, rather than reticulate.
- Thallus with large cavities formed by splitting of the internal tissue.

The classification system of Hässel de Menendez places *Folioceros* in its own family **Foliocerotaceae** and order **Foliocerotales**. This classification is based on a cladistic morphological analysis, but has not been generally accepted or supported by additional research in the literature. For the present, *Folioceros* is usually placed in the Anthocerotaceae.

Chapter- 4

Leiosporoceros, Megaceros and Notothylas

Leiosporoceros

Leiosporoceros	
Scientific classification	
Kingdom:	Plantae
Division:	Anthocerotophyta
Class:	**Leiosporocerotopsida** Stotler & Crand.-Stotl. *emend* Duff
Order:	**Leiosporocerotales** Hässel
Family:	**Leiosporocerotaceae** Hässel
Genus:	***Leiosporoceros*** Hässel
Species:	***L. dussii***
Binomial name	
Leiosporoceros dussii (Steph.) Hässel	
Synonyms	

- *Anthoceros dussii* Steph.

Leiosporoceros dussii is the only species in the hornwort genus ***Leiosporoceros***. The species is placed in a separate family, order, and class for being "genetically and morphologically distinct from all other hornwort lineages." Cladistic analysis of genetic data supports a position at the very base of the hornwort clade. Physical characteristics that distinguish the group include unusually small spores that are *monolete* and unornamented. Additionally, there are unique strands of *Nostoc* (cyanobacteria) that grow inside the plant parallel with its direction of growth. Male plants have not yet been found.

Megaceros

Megaceros	
Scientific classification	
Kingdom:	Plantae
Division:	Anthocerotophyta
Class:	Anthocerotopsida
Order:	Dendrocerotales
Family:	Dendrocerotaceae
Genus:	***Megaceros*** Campbell
Species	
Megaceros alatifrons Steph.	
Megaceros denticulatus	
Megaceros flagellaris (Mitt.) Steph.	
Megaceros gracilis	
Megaceros guatemalensis Steph.	
Megaceros novae-zelandiae Steph.	
Megaceros pallens (Steph.) Steph.	
Megaceros pellucidus (Colenso) E.A. Hodgs.	
Megaceros salakensis D. Campb.	
Megaceros tjibodensis D. Campb.	

Megaceros is a genus of hornworts in the family Dendrocerotaceae. The genus is found in the Old World tropics of east Asia and Australia. Its name means 'big horn', and refers both to the exceptionally large size of the gametophyte thallus and to the large, horn-shaped sporophyte that the plants produce. Many species have a branching thallus that is more than two centimeters wide. The gametophytes are monoicous.

The genus *Megaceros* is unusual among hornworts in that the sporophyte does not have stomata, and the spores are green because they contain chloroplasts, as does the related genus *Dendroceros*. The thallus cells often contain more than one chloroplast, as opposed to other hornwort genera. The elaters are helical.

The genus *Megaceros* was first recognized in 1907 by D. Campbell. More recently, the genera *Nothoceros* and *Phaeomegaceros* have been split off from this genus. The former genus includes all New World species previously included in *Megaceros*.

Notothylas

Notothylas	
Scientific classification	
Kingdom:	Plantae
Division:	Anthocerotophyta
Class:	Anthocerotopsida
Order:	Notothyladales
Family:	Notothyladaceae
Genus:	***Notothylas*** Sull.
Species	

Notothylas anaporata
Notothylas breutellii
Notothylas chaudhurii
Notothylas dissecta
Notothylas flabellata
Notothylas himalayensis
Notothylas indica
Notothylas japonicus
Notothylas javanicus
Notothylas khasiana
Notothylas levieri
Notothylas orbicularis
Notothylas pandei
Notothylas pfleidereri

Notothylas is a genus of hornworts in the family Notothyladaceae. The genus is found globally, but is usually overlooked. It is the smallest of all the hornworts, with a yellow-green gametophyte thallus that is seldom more than a centimeter in diameter, and usually much smaller.

The genus *Notothylas* is also unusual among hornworts in that the sporophyte is bullet-shaped and does not grow very large (less than two millimeters). The sporophytes grow outwards rather than upwards, and like *Megaceros*, there are no stomata on the surface of the sporophyte. The elater cells do not grow helical thickenings.

A number of classification systems place *Notothylas* in its own order Notothyladales (frequently misspelled *Notothylales* in the literature). This classification is based on the assumption that the unique physical characteristics of the genus reflect an early divergence from other hornworts. However, this assumption is not supported by either phylogenetic analysis or fossil evidence. More recent classifications expand the definition of the family Notothyladaceae to include four other genera.

Chapter- 5

Moss

Moss Temporal range: Carboniferous – recent

"Muscinae" from Ernst Haeckel's *Kunstformen der Natur*, 1904
Scientific classification
Kingdom: Plantae
Division: **Bryophyta** Schimp.
Classes

- Takakiopsida
- Sphagnopsida
- Andreaeopsida
- Andreaeobryopsida

- Oedipodiopsida
- Polytrichopsida
- Tetraphidopsida
- Bryopsida

Mosses are small, soft plants that are typically 1–10 cm (0.4–4 in) tall, though some species are much larger. They commonly grow close together in clumps or mats in damp or shady locations. They do not have flowers or seeds, and their simple leaves cover the thin wiry stems. At certain times mosses produce spore capsules which may appear as beak-like capsules borne aloft on thin stalks.

There are approximately 12,000 species of moss classified in the **Bryophyta**. The division *Bryophyta* formerly included not only mosses, but also liverworts and hornworts. These other two groups of bryophytes now are often placed in their own divisions.

Physical characteristics

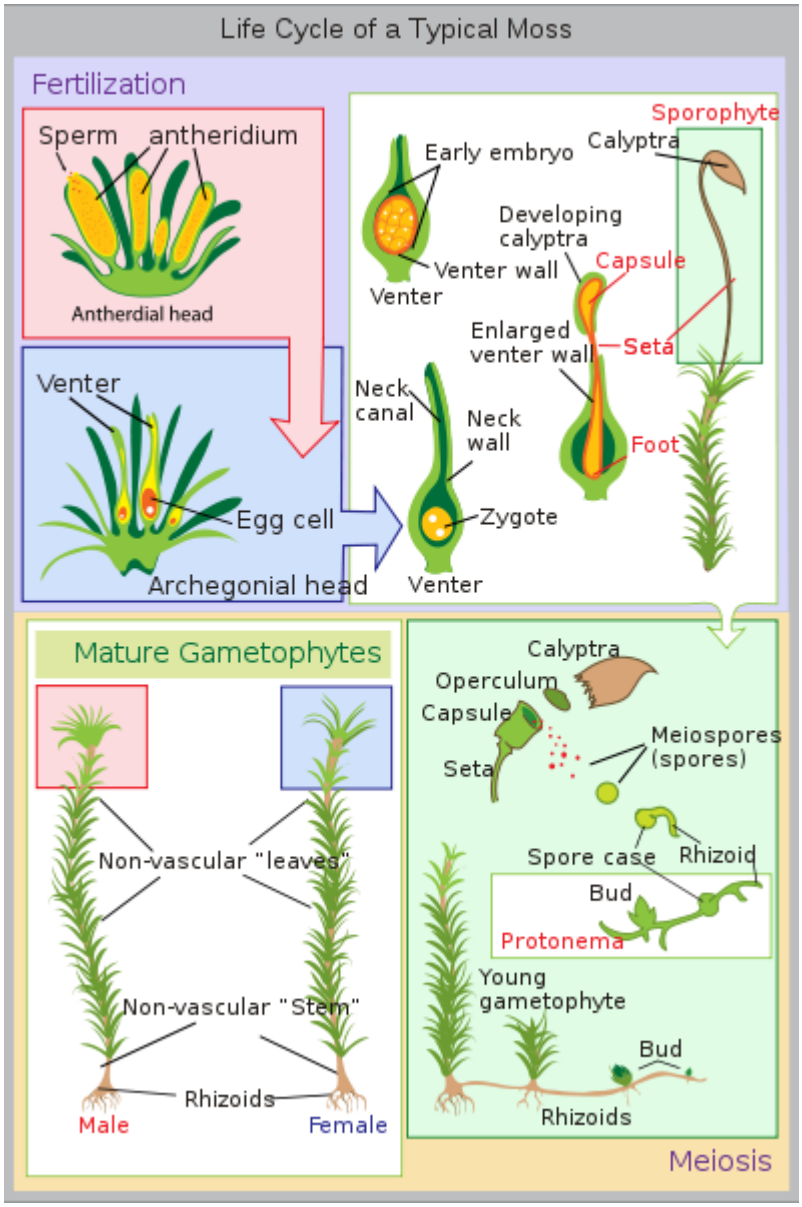
Description

Botanically, mosses are bryophytes, or non-vascular plants. They can be distinguished from the apparently similar liverworts (Marchantiophyta or Hepaticae) by their multi-cellular rhizoids. Other differences are not universal for all mosses and all liverworts, but the presence of clearly differentiated "stem" and "leaves", the lack of deeply lobed or segmented leaves, and the absence of leaves arranged in three ranks, all point to the plant being a moss.

In addition to lacking a vascular system, mosses have a gametophyte-dominant life cycle, i.e. the plant's cells are haploid for most of its life cycle. Sporophytes (i.e. the diploid body) are short-lived and dependent on the gametophyte. This is in contrast to the pattern exhibited by most "higher" plants and by most animals. In seed plants, for example, the haploid generation is represented by the pollen and the ovule, whilst the diploid generation is the familiar flowering plant.

Life cycle

Most kinds of plants have two sets of chromosomes in their vegetative cells and are said to be diploid, i.e. each chromosome has a partner that contains the same, or similar, genetic information. By contrast, mosses and other bryophytes have only a single set of chromosomes and so are haploid (i.e. each chromosome exists in a unique copy within the cell). There are periods in the moss life cycle when they do have a double set of paired chromosomes, but this happens only during the sporophyte stage.



Life cycle of a typical moss (*Polytrichum commune*)

The life of a moss starts from a haploid spore. The spore germinates to produce a protonema (*pl.* protonemata), which is either a mass of thread-like filaments or thalloid (flat and thallus-like). Moss protonemata typically look like a thin green felt, and may grow on damp soil, tree bark, rocks, concrete, or almost any other reasonably stable surface. This is a transitory stage in the life of a moss, but from the protonema grows the gametophore ("gamete-bearer") that is structurally differentiated into stems and leaves. A single mat of protonemata may develop several gametophore shoots, resulting in a clump of moss.

From the tips of the gametophore stems or branches develop the sex organs of the mosses. The female organs are known as archegonia (*sing.* archegonium) and are

protected by a group of modified leaves known as the perichaetum (plural, perichaeta). The archegonia are small flask-shaped clumps of cells with an open neck (venter) down which the male sperm swim. The male organs are known as antheridia (*sing.* antheridium) and are enclosed by modified leaves called the perigonium (*pl.* perigonia). The surrounding leaves in some mosses form a splash cup, allowing the sperm contained in the cup to be splashed to neighboring stalks by falling water droplets.

Mosses can be either dioicous (compare dioecious in seed plants) or monoicous (compare monoecious). In dioicous mosses, male and female sex organs are borne on different gametophyte plants. In monoicous (also called autoicous) mosses, both are borne on the same plant. In the presence of water, sperm from the antheridia swim to the archegonia and fertilisation occurs, leading to the production of a diploid sporophyte. The sperm of mosses is biflagellate, i.e. they have two flagellae that aid in propulsion. Since the sperm must swim to the archegonium, fertilisation cannot occur without water. After fertilisation, the immature sporophyte pushes its way out of the archegonial venter. It takes about a quarter to half a year for the sporophyte to mature. The sporophyte body comprises a long stalk, called a seta, and a capsule capped by a cap called the operculum. The capsule and operculum are in turn sheathed by a haploid calyptra which is the remains of the archegonial venter. The calyptra usually falls off when the capsule is mature. Within the capsule, spore-producing cells undergo meiosis to form haploid spores, upon which the cycle can start again. The mouth of the capsule is usually ringed by a set of teeth called peristome. This may be absent in some mosses. Most mosses rely on the wind to disperse the spores. In the genus *Sphagnum* the spores are projected about 10 to 20 cm off the ground by compressed air contained in the capsules; the spores are accelerated to about 36,000 times the gravitational constant.

In some mosses, e.g. *Ulota phyllantha*, green vegetative structures called gemmae are produced on leaves or branches, which can break off and form new plants without the need to go through the cycle of fertilization. This is a means of asexual reproduction, and the genetically identical units can lead to the formation of clonal populations.

Classification

Traditionally, mosses were grouped with the liverworts and hornworts in the Division **Bryophyta** (bryophytes), within which the mosses made up the class Musci. This definition of Bryophyta, however, is paraphyletic and now tends to be split up into three divisions. In such a system, the Division Bryophyta contains exclusively mosses.

Moss in the Allegheny National Forest, Pennsylvania, USA.

Six of the eight classes contain only one or two genera each. Polytrichopsida includes 23 genera, and Bryopsida includes the majority of moss diversity with over 95% of moss species belonging to this class.

The Sphagnopsida, the peat-mosses, comprise the two living genera *Ambuchanania* and *Sphagnum*, as well as fossil taxa. However, the genus *Sphagnum* is a diverse, widespread, and economically important one. These large mosses form extensive acidic bogs in peat swamps. The leaves of *Sphagnum* have large dead cells alternating with living photosynthetic cells. The dead cells help to store water. Aside from this character, the unique branching, thallose (flat and expanded) protonema, and explosively rupturing sporangium place it apart from other mosses.

Andreaeopsida and Andreaeobryopsida are distinguished by the biseriate (two rows of cells) rhizoids, multiseriate (many rows of cells) protonema, and sporangium that splits along longitudinal lines. Most mosses have capsules that open at the top.

Polytrichopsida have leaves with sets of parallel lamellae, flaps of chloroplast-containing cells that look like the fins on a heat sink. These carry out photosynthesis and may help to conserve moisture by partially enclosing the gas exchange surfaces. The Polytrichopsida differ from other mosses in other details of their development and anatomy too, and can

also become larger than most other mosses, with e.g. *Polytrichum commune* forming cushions up to 40 cm (16 in) high. The tallest land moss, a member of the Polytrichidae is probably *Dawsonia superba*, a native to New Zealand and other parts of Australasia.

They appear to be the closest living relatives of the vascular plants.

Red moss capsules, a winter native of the Yorkshire Dales moorland

Geological history

The fossil record of moss is sparse, due to their soft-walled and fragile nature. Unambiguous moss fossils have been recovered from as early as the Permian of Antarctica and Russia, and a case is put forwards for Carboniferous mosses. It has further been claimed that tube-like fossils from the Silurian are the macerated remains of moss calyptræ.

Habitat

Dense moss colonies in a cool coastal forest

A closeup of moss on a rock

Young sporophytes of the common moss *Tortula muralis* (wall screw-moss)

Retaining wall covered in moss

A small clump of moss

Mosses are found chiefly in areas of dampness and low light. Mosses are common in wooded areas and at the edges of streams. Mosses are also found in cracks between paving stones in damp city streets. Some types have adapted to urban conditions and are found only in cities. A few species are wholly aquatic, such as *Fontinalis antipyretica*, and others such as *Sphagnum* inhabit bogs, marshes and very slow-moving waterways. Such aquatic or semi-aquatic mosses can greatly exceed the normal range of lengths seen in terrestrial mosses. Individual plants 20–30 cm (8–12 in) or more long are common in *Sphagnum* species for example.

Wherever they occur, mosses require moisture to survive because of the small size and thinness of tissues, lack of cuticle (waxy covering to prevent water loss), and the need for liquid water to complete fertilisation. Some mosses can survive desiccation, returning to life within a few hours of rehydration.

In northern latitudes, the north side of trees and rocks will generally have more moss on average than other sides (though south-side outcroppings are not unknown). This is assumed to be because of the lack of sufficient water for reproduction on the sun-facing side of trees. South of the equator the reverse is true. In deep forests where sunlight does not penetrate, mosses grow equally well on all sides of the tree trunk.

Cultivation

Moss is considered a weed in grass lawns, but is deliberately encouraged to grow under aesthetic principles exemplified by Japanese gardening. In old temple gardens, moss can carpet a forest scene. Moss is thought to add a sense of calm, age, and stillness to a garden scene. Rules of cultivation are not widely established. Moss collections are quite often begun using samples transplanted from the wild in a water-retaining bag. However, specific species of moss can be extremely difficult to maintain away from their natural sites with their unique combinations of light, humidity, shelter from wind, etc.

Growing moss from spores is even less controlled. Moss spores fall in a constant rain on exposed surfaces; those surfaces which are hospitable to a certain species of moss will typically be colonised by that moss within a few years of exposure to wind and rain. Materials which are porous and moisture retentive, such as brick, wood, and certain coarse concrete mixtures are hospitable to moss. Surfaces can also be prepared with acidic substances, including buttermilk, yogurt, urine, and gently puréed mixtures of moss samples, water and ericaceous compost.

Inhibiting moss growth

Moss growth can be inhibited by a number of methods:

- Decreasing availability of water through drainage or direct application changes.
- Increasing direct sunlight.
- Increasing number and resources available for competitive plants like grasses.
- Increasing the soil pH with the application of lime.

Heavy traffic or manually disturbing the moss bed with a rake will also inhibit moss growth.

The application of products containing ferrous sulfate or ferrous ammonium sulfate will kill moss; these ingredients are typically in commercial moss control products and fertilizers. Sulfur and Iron are essential nutrients for some competing plants like grasses. Killing moss will not prevent regrowth unless conditions favorable to their growth are changed.

Mossery

A passing fad for moss-collecting in the late 19th century led to the establishment of mosseries in many British and American gardens. The mossery is typically constructed out of slatted wood, with a flat roof, open to the north side (maintaining shade). Samples of moss were installed in the cracks between wood slats. The whole mossery would then be regularly moistened to maintain growth.

Commercial use

There is a substantial market in mosses gathered from the wild. The uses for intact moss are principally in the florist trade and for home decoration. Decaying moss in the genus *Sphagnum* is also the major component of peat, which is "mined" for use as a fuel, as a horticultural soil additive, and in smoking malt in the production of Scotch whisky.

Sphagnum moss, generally the species *cristatum* and *subnitens*, is harvested while still growing and is dried out to be used in nurseries and horticulture as a plant growing medium. The practice of harvesting *peat moss* should not be confused with the harvesting of *moss peat*. *Peat moss* can be harvested on a sustainable basis and managed so that regrowth is allowed, whereas the harvesting of *moss peat* is generally considered to cause significant environmental damage as the peat is stripped with little or no chance of recovery.

In World War I, *Sphagnum* mosses were used as first-aid dressings on soldiers' wounds, as these mosses are highly absorbent and have mild antibacterial properties. Some early people used it as a diaper due to its high absorbency.

In rural UK, *Fontinalis antipyretica* was traditionally used to extinguish fires as it could be found in substantial quantities in slow-moving rivers and the moss retained large volumes of water which helped extinguish the flames. This historical use is reflected in its specific Latin/Greek name, the approximate meaning of which is "against fire".

In Finland, peat mosses have been used to make bread during famines.

In Mexico, Moss is used as a Christmas decoration.

Moss photobioreactor with *Physcomitrella patens*

Physcomitrella patens is increasingly used in biotechnology. Prominent examples are the identification of moss genes with implications for crop improvement or human health and the safe production of complex biopharmaceuticals in the moss bioreactor, developed by Ralf Reski and his co-workers.

Chapter- 6

Takakia and Bryopsida

Takakia

Takakia	
Scientific classification	
Kingdom:	Plantae
Division:	Bryophyta
Class:	**Takakiopsida** Stech & W. Frey
Order:	**Takakiales** Stech & W. Frey
Family:	**Takakiaceae** Stech & W. Frey
Genus:	***Takakia*** S. Hatt. & Inoue
Species	
T. ceratophylla *T. lepidozioides*	

Takakia is a genus of only two species of moss known from western North America and central and eastern Asia. The genus is placed as a separate family, order and class among the mosses. It has had a history of uncertain placement, but the discovery of sporophytes clearly of the moss-type firmly supports placement with the mosses.

Discovery

Takakia was discovered in the Himalayas and described by Mitten in 1861. It was originally described simply as a new liverwort species (*Lepidozia ceratophylla*) within an existing genus, and it was thus long overlooked. The discovery of similar odd plants in the mid-20th century by Dr. Takaki in Japan sparked more interest. The many unusual features of these plants led to the establishment in 1958 of the species *Takakia*

lepidozioides, in a new genus *Takakia*, named to honor the man who rediscovered it and recognized its unique characteristics. The species originally described by Mitten was subsequently recognized by Grolle as belonging to this new genus, and accordingly renamed *Takakia ceratophylla*.

All of the plants originally collected lacked any reproductive structures; they were sterile gametophyte plants. Eventually, plants with archegonia were found, which resembled the archegonia found in mosses. Fertile plants bearing antheridia and sporophytes were first reported in 1993 from the Aleutian Islands, and both structures were clearly of the form found in primitive mosses. This discovery established *Takakia* as a genus of moss, albeit an unusual one.

In Asia, *Takakia* has since been found in Sikkim (in the Himalayas), North Borneo, Taiwan, and Japan. In North America, the genus is found in the Aleutian Islands and British Columbia. It occurs in a variety of local habitats, from bare rock, to moist humus, and grows at elevations ranging from sea level to the subalpine.

Description

Takakia is not only unusual among mosses, but among all living plants. The plant's Japanese name (*nanjamonja-goke*) "impossible moss" reflects this. It was believed to have the lowest known chromosome count (n=4) per cell of any land plant., but some plants of the small Australian daisy *Brachyscome dichromosomatica* are now known to have a count of n=2.

From a distance, *Takakia* looks like a typical layer of moss or green algae on the rock where it grows. On closer inspection, tiny shoots of *Takakia* grow from a turf of slender, creeping rhizomes. The green shoots which grow up from the turf are seldom taller than 1 cm, and bear an irregular arrangement of short, finger-like leaves (1 mm long). These leaves are deeply divided into two or more filaments, a characteristic not found in any other moss. Both the green shoots and their leaves are very brittle.

Unlike in other bryophytes, the egg-producing archegonia and sperm-producing antheridia are not surrounded by perichaetial leaves or other protective tissues. Instead, the gametangia are naked in the angle formed between the stem and the vegetative leaves. The sporophyte develops a long stalk ending in an elongated spore capsule. The capsule contains a central columella ("little column") over and around which the spores are produced. When the sporophyte is mature, the capsule ruptures along a single, spiral slit to release the spores.

Bryopsida

Bryopsida

Arthrodontous capsule of *Dicranella varia*
Scientific classification
Kingdom: Plantae
Division: Bryophyta
Class: **Bryopsida** (Limpr.) Rothm.
Subclasses
Bryidae Buxbaumiidae Dicranidae Diphysciidae Funariidae Timmiidae

The **Bryopsida** constitute the largest class of mosses, containing 95% of all moss species. It consists of approximately 11,500 species, common throughout the whole world.

The group is distinguished by having spore capsules with teeth that are *arthrodontous*; the teeth are separate from each other and jointed at the base where they attach to the opening of the capsule. These teeth are exposed when the covering operculum falls off. In other groups of mosses, the capsule is either *nematodontous* with an attached operculum, or else splits open without operculum or teeth.

Capsule structure

Among the Bryopsida, the structure of the capsule (sporangium) and its pattern of development is very useful both for classifying and for identifying moss families. Most Bryopsida produce a capsule with a lid (the operculum) which falls off when the spores inside are mature and thus ready to be dispersed. The opening thus revealed is called the *stoma* (meaning "mouth") and is surrounded by one or two peristomes. A peristome is a ring of triangular "teeth" formed from the remnants of specially thickened cell walls.

There are usually 16 such teeth in a single peristome, and in the Bryopsida the teeth are separate from each other and able to both fold in to cover the stoma as well as fold back to open the stoma. This articulation of the teeth is termed **arthrodontous**.

There are two basic arthrodontous peristome types. The first type is termed **haplolepidous** and consists of a single circle of 16 peristome teeth. This type of peristome is characteristic of subclass Dicranidae. The second type is the **diplolepidous** peristome found in subclasses Bryidae, Funariidae, and Timmiidae. In this type, there are two rings of peristome teeth—an inner **endostome** (short for *endoperistome*) and an **exostome**. The endostome is a more delicate membrane, and its teeth are aligned between the teeth of the exostome. There are a few mosses in the Bryopsida that have no peristome in their capsules. These mosses still undergo the same cell division patterns in capsule development, but the teeth do not fully develop.

Chapter- 7

Sphagnum

Sphagnum	

Sphagnum flexuosum

Scientific classification	
Kingdom:	Plantae
Phylum:	Bryophyta
Class:	Sphagnopsida
Subclass:	Sphagnidae
Order:	Sphagnales
Family:	Sphagnaceae
Genus:	***Sphagnum*** L.

Species

Sphagnum affine
Sphagnum angustifolium
Sphagnum girgensohnii
Sphagnum magellanicum
Sphagnum novo-caledoniae
Sphagnum russowii

Sphagnum is a genus of between 151 and 350 species of mosses commonly called **peat moss**, due to its prevalence in peat bogs and mires. A distinction is made between

sphagnum moss, the live moss growing on top of a peat bog on one hand, and *sphagnum peat moss* (North American usage) or sphagnum peat (British usage) on the other, the latter being the decaying matter underneath. Bogs are dependent on precipitation as their main source of nutrients, thus making them a favourable habitat for sphagnum as it can retain water and air quite well. Members of this genus can hold large quantities of water inside their cells; some species can hold up to 20 times their dry weight in water, which is why peat moss is commonly sold as a soil conditioner. The empty cells help retain water in drier conditions. In wetter conditions, the spaces contain air and help the moss float for photosynthetic purposes. Sphagnum and the peat formed from it do not decay readily because of the phenolic compounds embedded in the moss's cell walls. An additional reason is that the bogs in which *Sphagnum* grows are submerged, deoxygenated, and favor slower anaerobic decay rather than aerobic microbial action. Peat moss can also acidify its surroundings by taking up cations such as calcium and magnesium and releasing hydrogen ions.

Common Sundew in a *Sphagnum* moss cushion

Individual peat moss plants consist of a main stem, with tightly arranged clusters of branch fascicles usually consisting of two or three spreading branches and two to four hanging branches. The top of the plant, or capitulum, has compact clusters of young branches. Along the stem are scattered leaves of various shape, named stem leaves; the shape varies according to species. The leaves consist of two kinds of cell; small, green,

living cells (chlorophyllose cells), and large, clear, structural, dead cells (hyaline cells). The latter have the large water-holding capacity.

Life Cycle

Sphagnum, like all other land plants, has an alternation of generations; like other bryophytes, it is the haploid gametophyte generation that is dominant and persistent. *Sphagnum* species can be unisexual (male or female, dioicous) or bisexual (male and female gametes produced from the same plant; monoicous); In North America, 80% of *Sphagnum* species are unisexual. Gametophytes have substantial asexual reproduction by fragmentation, producing much of the living material in *Sphagnum* peatlands. Swimming sperm fertilize eggs contained in archegonia that remain attached to the female gametophyte. The sporophyte is relatively short-lived, and consists entirely of a shiny black, spherical spore capsule. Sporophytes are raised on stalks to facilitate spore dispersal, but unlike other mosses, *Sphagnum* stalks are produced by the maternal gametophyte. Tetrahedral haploid spores are produced in the sporophyte by meiosis, which are then dispersed when the capsule ruptures.

Taxonomy and Phylogeny

Peat moss can be distinguished from other moss species by its unique branch clusters. The plant and stem color, the shape of the branch and stem leaves, and the shape of the green cells are all characteristics used to identify peat moss to species. *Sphagnum* taxonomy has been very contentious since the early 1900s; most species require microscopic dissection to be identified. In the field, most *Sphagnum* species can be identified to one of four major sections of the genus—classification and descriptions follow Andrus 2007 (Flora North America):

Red Sphagnum Closeup

- *Sphagnum* sect. *Acutifolia*: plants generally form hummocks above the water line, usually colored orange or red. Examples: *Sphagnum fuscum Sphagnum warnstorfii*
- *Sphagnum* sect. *Cuspidata*: plants usually in hollows, lawns, or aquatic; plants green. Examples: *Sphagnum cuspidatum*, *Sphagnum flexuosum*
- *Sphagnum* sect. *Sphagnum*: largest gametophytes among the sections, forming large hummocks, leaves with cuculate (hood-shaped) apices. Green, except for *Sphagnum magellanicum* Examples: *Sphagnum austinii*
- *Sphagnum* sect. *Subsecunda*: plants various colors, from green to yellow and orange (but never red), found in hollows, lawns, or aquatic. Species always with unisexual gametophytes. Examples: *Sphagnum lescurii*, *Sphagnum pylaesii*.

The reciprocal monophyly of these sections and two other minor ones (*Rigida* and *Squarrosa*) has been resolved using molecular phylogenetics. All but two species normally identified as *Sphagnum* reside in one clade, two other species have recently been separated into new families within the Sphagnaceae reflecting an ancestral relationship with the Tazmanian endemic Ambuchanania and long phylogenetic distance to the rest of *Sphagnum*. Within main clade of *Sphagnum* there is relatively short phylogenetic distance, and molecular dating methods suggest nearly all current *Sphagnum* species are descended from a radiation that occurred just 14 mya. This is controversial due to the poor construction and calibration of the genetic clock. Normal and correctly used genetic clocks employ a series of genes with determined substitution rates, in this work Shaw et al. used nuclear, mitochondrial and chloroplast genes with a mean substitution rate. The problem arises when a chloroplast gene with low substitution rate is analyzed with a nuclear substitution rate (which is extremely high) it would give a more recent date since the analysis would conclude that less mutations means a more recent divergence and evolution.

Geographic distribution

Peat mosses occur mainly in the Northern Hemisphere where different species dominate the top layer of peat bogs and moist tundra areas. The northernmost populations of peat moss lie in the archipelago of Svalbard, Arctic Norway at 81° N.

In the Southern Hemisphere, the largest peat moss areas are in New Zealand, Tasmania, southernmost Chile and Argentina, but contain comparatively few species. Many species are reported from mountainous, subtropical Brazil, but uncertainty exists regarding the specific status of many of them.

Spore dispersal

As do many other mosses, *Sphagnum* disperses its spores through the wind, but the tops of spore capsules are only about 1 cm above ground, and the wind is too weak that low. As the spherical spore capsule dries, the operculum is forced off, followed by a cloud of spores. The exact mechanism has traditionally attributed to a "pop gun" method using air compressed in the capsule, reaching a maximum velocity of 3.6 meters per second, but

alternative mechanisms have been recently proposed. High speed photography has shown that vortex rings are created during the discharge, which enable the spores to reach a height of 10 to 20 cm, further than would be expected by ballistics alone. The acceleration of the spores is about 36,000g. Spores are extremely important in establishment of new populations in disturbed habitats and on islands.

Uses

Peat moss soil amendment, made of decayed, compacted *Sphagnum* moss

Decayed, compacted *Sphagnum* moss has the name of peat or peat moss. This is used as a soil conditioner which increases the soil's capacity to hold water and nutrients by increasing capillary forces and cation exchange capacity (CEC). This is often necessary when dealing with very sandy soil, or plants that need an increased moisture content to flourish. One such group of plants are the carnivorous plants, often found in wetlands (bogs for example). Dried *Sphagnum* moss is also used in northern Arctic regions as an insulating material. Peat moss is also a critical element for growing mushrooms; mycelium grows in compost with a layer of peat moss on top, through which the mushrooms come out, a process called pinning.

Anaerobic acidic *Sphagnum* bogs are known to preserve mammalian bodies extremely well for millennia. Examples of these preserved specimens are Tollund Man, Haraldskær Woman, Clonycavan Man and Lindow Man. Such *Sphagnum* bogs can also preserve human hair and clothing, one of the most noteworthy examples being Egtved Girl, Denmark. Because of the acidity of peat, however, bones are dissolved rather than

preserved. These bogs have also been used to preserve food. Bog butters have been found in Scottish and Irish peat bogs. Containing butter or lard, bog butters have been found that are up to 2000 years old.

Sphagnum moss has also been used for centuries as a dressing for wounds, including during both World Wars. It is absorptive and extremely acidic, inhibiting the growth of bacteria and fungi.

Sphagnum moss is used as an environmentally-friendly alternative to chlorine in swimming pool sanitation. The moss inhibits the growth of microbes and reduces or eliminates the need for chlorine in swimming pools.

Peat moss is used to dispose of the clarified liquid output (effluent) from septic tanks in areas that lack the proper soil to support an ordinary disposal means or for soils that were ruined by previous improper maintenance of existing systems.

In New Zealand, both the species *S. cristatum* and *S. subnitens* are harvested by hand and exported worldwide for use as hanging basket liners, as a growing medium for young orchids, and mixed in with other potting mixes to enhance their moisture retaining value.

It is also used at horse stables as a bedding in horse stalls. It is not a very common bedding, but some farm owners choose peat moss to compost with horse manure.

It can also be used as a substrate for tarantulas as it is easy to burrow into and contains no insecticides which could kill the spider.

There is a difference in naming conventions for similar things related to sphagnum moss. The terms that people use when referring to moss peat, peat moss, and bog moss can be taken out of context and be used when reference is actually being made about a plant that is still growing, as opposed to the decayed and compressed plant material. These terms are commonly used for both forms of the same plant material, resulting in confusion as to what the speaker is actually talking about.

Conservation

Mer Bleue Conservation Area, a large protected *Sphagnum* bog near Ottawa, Ontario, Canada.

Large-scale peat harvesting is not sustainable as it takes thousands of years to form the peat "bricks" that are harvested in just a week. In particular, the extraction of large quantities of moss is a threat to raised bogs. Coir has been touted as a sustainable alternative to peat moss in growing media. Another peat moss alternative is manufactured in California from sustainably harvested redwood fiber and sold under the brand name LignaPeat.

During the 17th century in the Dutch Republic, peat bogs were drained to feed a burgeoning peat mining industry. The system of dikes and waterways existing today in the Netherlands was once a peat bog.

More than 90% of the bogs in England have been damaged or destroyed. A handful of bogs have been preserved through government buyouts of peat-mining interests.

New Zealand

Care is taken during the harvesting of *Sphagnum* moss in New Zealand to ensure that there is enough moss remaining to allow regrowth. This is commonly done using a 3 year cycle. If a good percentage of moss is not left for regrowth, the time that it takes for the swamp to revert to its original state can be up to a decade or more if serious damage has occurred.

This "farming" as done in New Zealand is based on a sustainable management program approved by New Zealand's Department of Conservation. This plan ensures the regeneration of the moss, while protecting the wildlife and the environment. Most harvesting in New Zealand swamps is done only using pitchforks without the use of heavy machinery. During transportation, helicopters are commonly employed to transfer the newly harvested moss from the swamp to the nearest road. This is an important component of the transportation process, as it prevents damage to other components of the ecosystem during the initial transportation phase. The removal of sphagnum moss in a managed environment does not cause a swamp to dry out. In fact the swamp environment is improved such that the regrown moss is normally better quality than the previously harvested moss that was removed.

The greatest threat to the existence of sphagnum moss swamps is the intentional draining for encroaching farmland.

Health dangers

Sphagnum moss can potentially harbour the chronic fungal disease sporotrichosis. *Sporothrix schenckii* spores enter the skin via abrasions, scratches, and small puncture wounds as a result of unprotected contact exposure to *Sphagnum* moss.

Chapter- 8

Aulacomnium Palustre

Aulacomnium palustre

Scientific classification
Kingdom: Plantae
Division: Bryophyta
Class: Bryopsida
Subclass: Bryidae
Order: Bryales
Family: Aulacomniaceae
Genus: *Aulacomnium*
Species: ***A. palustre***
Binomial name
Aulacomnium palustre (Hedw.) Schwägr.

Aulacomnium palustre, or **Ribbed Bog Moss** is a moss that is nearly cosmopolitan in distribution. It occurs in North America, the Dominican Republic, Venezuela, Eurasia, and New Zealand. In North America, it occurs across southern arctic, subboreal, and boreal regions from Alaska and British Columbia to Greenland and Quebec. Documentation of ribbed bog moss's distribution in the contiguous United States is probably incomplete. It is reported sporadically south to Washington, Wyoming, Georgia, and Virginia.

Habitat types and plant communities

Ribbed bog moss is frequent in arctic to subboreal wetlands. Moss assemblages are typically diverse in northern (arctic, subarctic, and boreal) plant communities, and individual moss species often have low cover and/or frequency. Moss species with coverages of 2% to 4% can be common to dominant in boreal communities, although ribbed bog moss attains coverages as great as 40% in some boreal communities.

Ribbed bog moss grows in open and forested wetland communities. In unforested northern communities, ribbed bog moss is found in sedge (Carex spp.) meadows, sphagnum (Sphagnum spp.) peatlands, heath-sedge fens, and willow (Salix spp.)-dominated fens. In forests, ribbed bog moss grows in the ground layer of boreal and subboreal white spruce (Picea glauca), black spruce (P. mariana), mixed spruce-tamarack (Larix laricina), and jack pine (Pinus banksiana) fens and bogs of Alaska, Minnesota, and Canada and in boreal spruce-birch (Betula spp.) forests of Alaska and northwestern Canada. Mosses are abundant in taiga forests of interior Alaska and Canada, forming characteristic strata in nearly every taiga forest type.

Less is known of ribbed bog moss associations south and east of Minnesota, although ribbed bog moss has been noted in some swamp, coniferous and/or hardwood bog, and grassland communities. Ribbed bog moss grows in red maple (Acer rubrum) swamps of Long Island, New York, and Little listed ribbed bog moss as common (1-4% frequency) in Atlantic white-cedar (Chamaecyparis thyoides) swamps of southern New Jersey. Ribbed bog moss is also common in jack pine (Pinus banksiana), aspen (Populus spp.), and mixed-hardwood forests of the Great Lakes states and southern Canada. Ribbed bog moss grows on tallgrass prairie in Kansas and Arkansas. In the Pacific Northwest ribbed bog moss occurs in alpine, subalpine, wet and dry coniferous forest, and open peatland communities. In a survey of alpine and unforested subalpine communities of the North Cascade Range in Washington and British Columbia, ribbed bog moss occurred in graminoid, forb, heath, and willow communities.

General botanical characteristics

Mosses have 2 phases in their life cycle: the gametophyte (n) and sporophyte (2n) generations. Each generation is morphologically distinct.

Gametophytes

Ribbed bog moss stems comprise most of ribbed bog moss's biomass and are easily visible. Stems are erect and spreading in habit, forming clumps or lawns. They range from 1 to 4 inches (3-9 cm) long; most stems are vegetative but some bear reproductive organs. Short vegetative stems may end in a stalk bearing clusters of gemmae. Ribbed bog moss is heterothallic, with male and female reproductive organs borne on separate reproductive shoots. Male and female stems develop antheridia and archegonia, respectively, at their tips. Approximately the top 0.6 inch (1.5 cm) of both vegetative and reproductive stems is alive; lower stem tissue is usually dead. Ribbed bog moss leaves

are bright yellowish-green to green; their bright color sometimes gives ribbed bog moss an incandescent appearance ("glow moss"). Bright leaves that contrast starkly with the reddish-brown stems typically make ribbed bog moss the most conspicuous species in moss assemblages. The leaves are lanceolate in shape and often tomentose, becoming twisted and brown when dry. They range from 3 to 5 mm long. Ribbed bog moss anchors to the substrate with rhizoids. Because ribbed bog moss lacks vascular tissue, water uptake occurs by osmosis and capillary action. A network of capillary spaces between stems and rhizoids enhances water uptake; ribbed bog moss usually absorbs water more efficiently than associated sphagnum mosses.

Sporophytes

Sporophytes grow out of archegonia. The sporophyte consists of a foot that anchors the sporophyte to the archegonia, a stalk, and a spore capsule. Ribbed bog moss stalks are vertically straight and about 1.8 inches (4.5 cm) long. Ribbed bog moss is named for its distinct spore capsule, which is strongly ribbed, cylindrical, and about 4 mm long. The capsule is capped with a calyptra.

Regeneration processes

Ribbed bog moss regenerates sexually and vegetatively.

Gametophyte dispersal and establishment

A spore is the first growth stage of a developing gametophyte. When the spore capsule matures, ribbed bog moss's calyptra splits along the side, exposing spores. Release of the exposed spores requires dry weather and is governed by a row of "teeth" that ring the capsule's top. The capsule teeth are hygroscopic, bending outward when air is dry and permitting spores to fall. Wind disperses ribbed bog moss spores long distances by shaking the capsule. When air is moist, the teeth bend inward, holding the spores within the capsule. The spores require a moist substrate to germinate. A germinated spore develops into a protonema (a branched, threadlike structure). Rhizoids grow down from the protonema and penetrate the substrate. Stems arise from buds that develop on the protonema surface. As stems grow, they develop their own rhizoids and become independent of the protonema. Mature male and female stems develop antheridia and archegonia, which produce sperm and eggs, respectively. Ribbed bog moss antheridia do not develop synchronously on the same stem. Mature and immature antheridia are intermixed on individual male shoots; therefore, sperm cells on the same stem do not all develop at the same time. However, sperm cells within a single antheridium have synchronous development. Fertilization requires a moist or saturated environment. Before fertilization, the antheridium absorbs water and swells, forcing the spore cap off. Rain may splash sperm into the archegonium, or sperm may swim to the archegonium.

Spore banking

Ribbed bog moss may germinate from spores stored in the substrate, but banked spores are probably less important to ribbed bog moss regeneration than freshly-dispersed spores. Ross-Davis and Frego found that annual dispersal deposited a far greater number of moss spores on boreal substrates compared to the number of spores buried in the spore bank.

Breeding system

Ribbed bog moss is dioicous.

Sporophyte development

Ribbed bog moss's sporophyte generation develops from the fertilized egg. Eggs are fertilized within the archegonium. The sporophyte embryo grows rapidly, differentiating into foot, stalk, and capsule tissue. Spores develop within the capsule.

Vegetative regeneration

Ribbed bog moss reproduces asexually from specialized gametophyte tissues and from plant breakage. It reproduces frequently from gemmae. Ribbed bog moss may also regenerate when paraphyses (minute filaments arising from ribbed bog moss's antheridia) detach. In the laboratory, 12.5% of detached ribbed bog moss paraphyses developed into propagules. Ribbed bog moss establishes readily when chunks of ribbed bog moss shoots are moved to new sites by soil movement or transplanting. Ribbed bog moss is apparently competitive in its ability to establish from stem chunks. In a laboratory experiment, ribbed bog moss that was collected from an Alberta peatland, shredded, and placed on a peat substrate showed greatest frequency (100%) of 4 moss species so treated. Ribbed bog moss also showed fastest growth relative to the other mosses throughout the 125-day experiment.

Growth

Ribbed bog moss growth is robust. It showed a "tall and dense growth habit" in a greenhouse common garden; ribbed bog moss, juniper hair cap moss (Polytrichum juniperinum), and papillose sphagnum (S. papillosum) crowded out 3 other moss species. Dry climate slows or stops ribbed bog moss growth. On the Boreal Ecosystem Research and Monitoring Sites study area in Saskatchewan, ribbed bog moss had a negative mean annual growth rate in a drought year (2003). Mean annual growth rate in a wet year (2004) was 2.7 mm. Ribbed bog moss was sensitive to saturated conditions in the wet year; stem lengths were greatest on relatively drier microsites, and ribbed bog moss growth rate increased slightly with increasing depth to the water table. Productivity measures of ribbed bog moss are provided in Fuels.

Site characteristics

Ribbed bog moss is a habitat generalist. It was, for example, 1 of 6 mosses having broad ecological amplitude in a survey of bryophyte habitats on peatlands across Alberta's Mackenzie River basin. Ribbed bog moss tolerates a wide range of moisture levels, substrates, nutrient loads, terrain, and climates.

Moisture regime

Ribbed bog moss generally grows on wetlands including fens, bogs, marshes, pond margins, streambanks, wet meadows, and riparian shrublands. In subalpine fir forests of central Idaho, ribbed bog moss occurs on seeps and springs that remain moist throughout the fire season [80,113]. Ribbed bog moss is an indicator species of wet to very wet soils in Canada [80,99]. In northern British Columbia, ribbed bog moss is an indicator species of undisturbed wet conifer sites [86]. The white spruce/field horsetail/ribbed bog moss association occurs on the wettest white spruce forests in subboreal British Columbia; the water table is near the soil surface for most of the growing season [115]. In a geothermal meadow on Queen Charlotte Island, British Columbia, ribbed bog moss occurred on sites with high local humidity (31-66%) due to nearby thermal pools. Ribbed bog moss did not grow on dry sites, although drained microsites may favor ribbed bog moss growth on otherwise saturated substrates. Ribbed bog moss does not tolerate salt spray, which prevents its establishment on coastal dunelands.

Ribbed bog moss is not confined to wet sites in all areas. Some forests with ribbed bog moss dry in late summer [80,99,115], and ribbed bog moss grows on relatively xeric hummock mounds on bogs in Bird's Hill Provincial Park, Manitoba [119]. Ribbed bog moss occupies both dry and wet sites on the Boreal Ecosystem Research and Monitoring Sites study area. It dominates relatively dry, shaded microsites in the area; the water table is 20 to 26 inches (50-65 cm) below ground, and there is 30% to 60% black spruce and/or tamarack cover.

Substrates

Ribbed bog moss is primarily a groundlayer species, but it does not require a particular substrate to establish and grow. It is most common on peat [2,15,112,122] but also grows on thinner organic soils [44,112] and other substrates [16,38,44,101]. Ribbed bog moss frequently grows on peat overlying permafrost in Alaska and northern Canada [2,112,122]. On northern peatlands, the peat layer generally ranges from 38 to 102 inches (15-40 cm) thick and organic content of the soil layer is high [80]. Studies on peatlands in Quebec showed ribbed bog moss "preferred sites with high organic matter depth" ($P<0.01$). Ribbed bog moss grows on organic surface layers overlying varying soil textures [21,112]. Ribbed bog moss also grows on burned substrates including ash [101], mineral soil, scorched organic soil, scorched peat and scorched downed woody debris [16,38].

Ribbed bog moss grows on peat and other organic soil layers more often than on downed bark or wood [99], but is reported growing on woody debris or other dead wood in a few locations. In northern British Columbia, ribbed bog moss substrates included disturbed forest floors, logs, and stumps at 44%, 13%, and 3% frequencies, respectively [86]. Ribbed bog moss was found on downed woody debris in a mixed quaking aspen-paper birch-balsam fir (Populus tremuloides-Betula papyrifera-Abies balsamifera) forest in east-central Alberta and on stumps in a mixed-hardwood forest in Wisconsin. Ribbed bog moss rarely grows on standing live or dead wood [99].

Ribbed bog moss showed broad substrate tolerances in a greenhouse common pot study in Scotland. Ribbed bog moss vegetative propagules were sown with propagules of 6 other mosses to test substrate preferences. After 1 year, ribbed bog moss abundance was similar on heather (Calluna vulgaris) litter, European white birch (Betula pendula) litter, dead shrub litter, Scots pine (Pinus sylvestris) needles, sand, and sphagnum peat substrates. To test particle-size microsite preferences on peat substrates, the peat was broken into various fragment sizes from minute to large (<0.25 inch to >2 inches (0.63-5 cm)). Ribbed bog moss grew on peat of all particle sizes but was most frequent on small (0.5-1 inch (1.25-2.5 cm)) peat particles.

Water and substrate chemistry

The pH of water, peat, and/or soil is usually acidic to neutral in mires with ribbed bog moss [2,33,51,51,52,112,133], although ribbed bog moss tolerates mildly alkaline conditions [33,133]. For example, ribbed bog moss grows in extremely acidic peatlands overlying permafrost in spruce taiga of Alaska [122] but also grows in calcareous bogs in Bird's Hill Provincial Park [119]. In Minnesota, ribbed bog moss is reported from bogs ranging from 5.0 to 7.3 in pH. A survey of bryophytes on peatlands across Alberta's Mackenzie River basin found ribbed bog moss was abundant on sites ranging from 4.5 to 7.5 in pH [92].

Mires are classified on pH and mineral gradients from extreme-poor (very strongly acid and low in calcium and magnesium) to extreme-rich (neutral to alkaline and high in calcium and magnesium) [72,110]. Fens are richer than bogs [68,91]. Ribbed bog moss occurs in poor [28,89] and rich [4,28,68] mires. On mires across British Columbia and Alberta, ribbed bog moss grows in mires with broad ranges of water pH and electrical conductivity, but is most common on strongly acidic peatlands (water pH <5.5) with moderate calcium and magnesium levels (<200 µS/cm**). Ribbed bog moss also grows in moderate-rich fens with higher pH and electrical conductivity values. In a peat-core study in central Alberta, macrofossil ribbed bog moss was an indicator species of moderate-rich fens; ribbed bog moss occurred most often on mires that were moderately acidic (x pH=6.0) and had low electrical conductivity (x=125 µS/cm) and moderately high water tables (x= 8.7 inches (22 cm) deep). In a study of alpine mires in Italy, ribbed bog moss was intermediate in mire pH and mineral content compared to associated nonvascular and vascular plant species, occurring on both poor and rich mires. All associated mosses had narrower pH and mineral tolerances than ribbed bog moss. Gignac provides information on ribbed bog moss habitats in British Columbia and Alberta

including ranges in pH, electrical conductivity, relative depth to the water table, and relative overstory cover.

Nutrients

Field observations and laboratory experiments suggest that ribbed bog moss has broad tolerance and may be relatively insensitive to macronutrient concentrations [49,78,121]. On the Svalbard archipelago in Norway, ribbed bog moss grows on small "bird islands" where eider ducks, arctic terns, and other migratory birds nest offshore of the main island, Spitsbergen. Nitrogen levels on the bird islands are very high. On Spitsbergen Island, however, ribbed bog moss grows on dry hummocks and moist hummock edges, both of which have low nitrogen levels [121] but probably provide moisture levels that favor ribbed bog moss. In a laboratory experiment, nitrogen fertilizer initially slowed ribbed bog moss growth rate, but growth rates of ribbed bog moss with and without nitrogen were similar at the end of 125 days. Addition of phosphorus had no effect on ribbed bog moss growth [78].

Ribbed bog moss is listed as an indicator species of nitrogen-medium soils in British Columbia [80].

Landscape

Tundra and taiga areas where ribbed bog moss grows are generally flat to gently sloped [42,112], but local relief creates drainage patterns that often result in distinct moss assemblages. Site geology—including topography, bedrock composition, catchment hydrology, and basin bathymetry—affects wetland drainage and partially controls rates of transition from open water to bog [71,131]. Ribbed bog moss is common on hummocks, which tend to dry out faster than adjacent lowlands [92,121]. In British Columbia and Alberta, ribbed bog moss often dominates hummock tops that are surrounded by sphagnum peatlands [50,89]. Although ribbed bog moss generally attains greatest coverage on hummock tops, it sometimes forms lawns and strings in low areas. In Labrador, tufted bulrush-mountain fly honeysuckle/ribbed bog moss associations occur on low strings of consolidated peat and on elevated peatlands. The low strings lie 38 to 76 inches (15-30 cm) above the water table and lack erosion patterns.

In Kluane National Park, Yukon, the white spruce/ribbed bog moss forest community occurs on poorly drained east- and north-facing slopes.

Elevation

There are few reports of ribbed bog moss's elevational tolerances. Ribbed bog moss is reported from 1,600 to 5,700 feet (500-1,750 m) in west-central Alberta and at 827 feet (252 m) in Kosciucko County, Indiana [123]. In subalpine and alpine communities of the North Cascade Range in Washington and British Columbia, ribbed bog moss occurs on high-elevation (>7,380 feet (2,250 m)) sites that remain snow-free most of the year.

Climate

Ribbed bog moss occurs in arctic, subarctic, boreal, and subboreal zones with cold mesothermal, oceanic, continental, or cold-humid climates [50,80,116]. It is more common in arctic, subarctic, and boreal than subboreal zones. A survey of bryophytes on peatlands across Alberta's Mackenzie River basin found optimal ribbed bog moss growth occurred on sites with annual temperatures ranging from 20 to 32 °F (-4 to 0 °C) [92]. In interior arctic, subarctic, and boreal zones, climate is strongly continental in the west, becoming more humid to the east. Climate shift from continental to humid generally occurs near Hudson Bay and Lake Superior [118,141]. In a study of moss habitats across British Columbia, Alberta, and Manitoba, ribbed bog moss was an indicator species for continentality of climate: it was the only moss common to all continental peatlands surveyed. On sites from coastal British Columbia to central Alberta, ribbed bog moss was most common on subcontinental sites (intermediate between coastal and continental climates). Ribbed bog moss was intermediate on gradients ranking breadth of moss habitat niches. Climate factors evaluated included length of growing season, amount of precipitation during the growing season, temperature, and aridity. Feather mosses (Hylocomiaceae) and sphagnum mosses generally had wider niches and dominated more sites than ribbed bog moss. Ribbed bog moss's rarity on all but cold sites in the lower 48 states suggests that ribbed bog moss does not tolerate long periods of warm weather. In a geothermal meadow on Queen Charlotte Island, British Columbia, ribbed bog moss was absent from sites where nearby thermal pools raised local soil temperatures above 86 °F (30 °C).

Uses

Importance to wildlife and livestock

Ribbed bog moss provides few known direct benefits to wildlife or livestock. Mosses in general are low in carbohydrates, proteins, and fats compared to vascular plants, and animals seldom graze them [82]. Caribou may eat mosses when little other forage is available [82,125]. Wildlife seeking cover probably avoid open areas dominated by ribbed bog moss or other low vegetation. In Wood Buffalo National Park, Alberta, aerial photos identified areas dominated by ribbed bog moss, bog Labrador tea, and/or Bebb willow as indicators of nonnesting habitat for whooping cranes [127].

American robins at the Mountain Lake Biological Station, Virginia, used ribbed bog moss as nest material.

Northern mires provide habitat for a variety of invertebrates including worms, crustaceans, arachnids, and insects, particularly mosquitoes, midges, and other flies [82].

Value for rehabilitation of disturbed sites

Chunks from ribbed bog moss lawns can be transplanted onto disturbed sites [5,78,89]. In Minnesota, moss plugs used in restoration projects on old peat mines are harvested from

nearby unmined sites in spring, before the ground thaws [111]. Although ribbed bog moss is not often used for restoration, it could be a valuable addition to restoration projects. Foote classified ribbed bog moss communities along the Alaskan Highway in Yukon as having "high site sensitivity", with moderate potential for erosion. Black spruce/ribbed bog moss communities on the Alaskan Pipeline are rated "sensitive to highly sensitive" to erosion and disturbance [112].

Chapter- 9

Buxbaumia and Funaria (Moss)

Buxbaumia

Buxbaumia	

Buxbaumia viridis

Scientific classification	
Kingdom:	Plantae
Division:	Bryophyta
Class:	Bryopsida
Subclass:	**Buxbaumiidae** Doweld
Order:	**Buxbaumiales** M. Fleisch.
Family:	**Buxbaumiaceae** Schimp.
Genus:	***Buxbaumia*** Hedw., 1801

Type species
B. aphylla

Hedw.

Buxbaumia (**Bug moss**, **Bug-on-a-stick**, **Humpbacked elves**, or **Elf-cap moss**) is the botanical name for a genus of twelve species of moss (Bryophyta). It was named in 1801 by Johann Hedwig to commemorate Johann Christian Buxbaum, a German physician and botanist who discovered the moss in 1712 at the mouth of the Volga River. The moss is microscopic for most of its existence, and plants are noticeable only after they begin to produce their reproductive structures. The asymmetrical spore capsule has a distinctive shape and structure, some features of which appear to be transitional from those in primitive mosses to most modern mosses.

Description

Plants of *Buxbaumia* have a much reduced gametophyte, bearing a sporophyte that is enormous by comparison. In most mosses, the gametophyte stage of the life cycle is both green and leafy, and is substantially larger than the spore-producing stage. Unlike these other mosses, the gametophyte of *Buxbaumia* is microscopic, colorless, stemless, and nearly leafless. It consists exclusively of thread-like protonemata for most of its existence, resembling a thin green-black felt on the surface where it grows. The plants are dioicous, with separate plants producing the male and female organs. Male plants develop only one microscopic leaf around each antheridium, and female plants produce just three or four tiny colorless leaves around each archegonium.

Because of its small size, the gametophyte stage is not generally noticed until the stalked sporangium develops, and is locatable principally because the sporangium grows upon and above the tiny gametophyte. The extremely reduced state of *Buxbaumia* plants raises the question of how it makes or obtains sufficient nutrition for survival. In contrast to most mosses, *Buxbaumia* does not produce abundant chlorophyll and is saprophytic. It is possible that some of its nutritional needs are met by fungi that grow within the plant.

The sporophyte at maturity is between 4 and 11 mm tall. The spore capsule is attached at the top of the stalk and is distinctive, being asymmetric in shape and oblique in attachment. As with most other Bryopsida, the opening through which the spores are released is surrounded by a double peristome (diplolepidious) formed from the cell walls of disintegrated cells. The exostome (outer row) consists of 16 short articulated "teeth". Unlike most other mosses, the endostome (inner row) does not divide into teeth, but rather is a continuous pleated membrane around the capsule opening. Only the genus *Diphyscium* has a similar peristome structure, although that genus has only 16 pleats in its endostome, in contrast to the 32 pleats in *Buxbaumia*. *Diphyscium* shares with *Buxbaumia* one other oddity of the sporophyte; the foot (stalk base) ramifies as a result of outgrowths, so much so that they may be mistaken for rhizoids.

Distribution and ecology

Sporophytes of *Buxbaumia aphylla* growing among other mosses. None of the visible leaves belong to *Buxbaumia*, which is a stemless and nearly leafless plant.

Species of *Buxbaumia* may be found across much of the temperate to subarctic regions of the Northern Hemisphere, as well as cooler regions of Australia and New Zealand.

The moss is an annual or biennial plant and grows in disturbed habitats or as a pioneer species. The plants grow on decaying wood, rock outcrops, or directly on the soil. They do not grow regularly or reliably at given locations, and frequently disappear from places where they have previously been found. Sporophyte stages begin their development in the autumn, and are green through the winter months. Spores are mature and ready for dispersal by the late spring or early summer. The spores are ejected from the capsule in puffs when raindrops fall upon the capsule's flattened top.

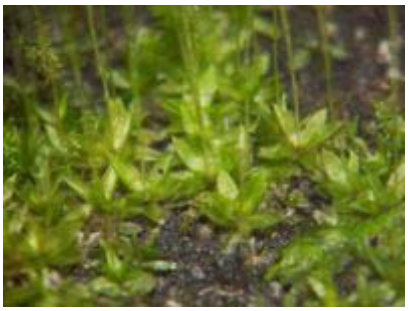
The asymmetric sporophytes of *Buxbaumia aphylla* develop so that the opening is oriented towards the strongest source of light, usually towards the south. The species often grows together with the diminutive liverwort *Cephaloziella*, which forms a blackish crust that is easier to spot than *Buxbaumia* itself.

Classification

Buxbaumia is the only genus in the family Buxbaumiaceae, the order Buxbaumiales, and the subclass Buxbaumiidae. It is the sister group to all other members of class Bryopsida.

Some older classifications included the Diphysciaceae within the Buxbaumiales (or as part of the Buxbaumiaceae) because of similarities in the peristome structure, or placed the Buxbaumiaceae in the Tetraphidales. Most recent cladistic studies using DNA sequences are not conclusive regarding the relationship between *Buxbaumia* and *Diphyscium*, but evidence suggests they are separate lines of a paraphyletic group. No recent studies favor a placement with the Tetraphidales.

Funaria

Funaria

Funaria hygrometrica
Scientific classification
Kingdom: Plantae
Division: Bryophyta
Class: Bryopsida
Subclass: Funariidae
Order: Funariales
Family: Funariaceae
Genus: ***Funaria***
Species
Funaria apophysata *Funaria hygrometrica*

Funaria is a genus of approximately 200 species of moss. *Funaria hygrometrica* is the most common species. *Funaria hygrometrica* is called "cord moss" because of the twisted seta which is very hygroscopic and untwists when moist. The name is derived from Latin word "funis" meaning a rope.

Capsules are abundant with the moss surviving as spore when conditions are not suitable.

Moss plant Funaria grows in dense patches or cushions in moist shady and cool places during the rainy season. It has a height of 3–5 cm, a radial symmetry with a

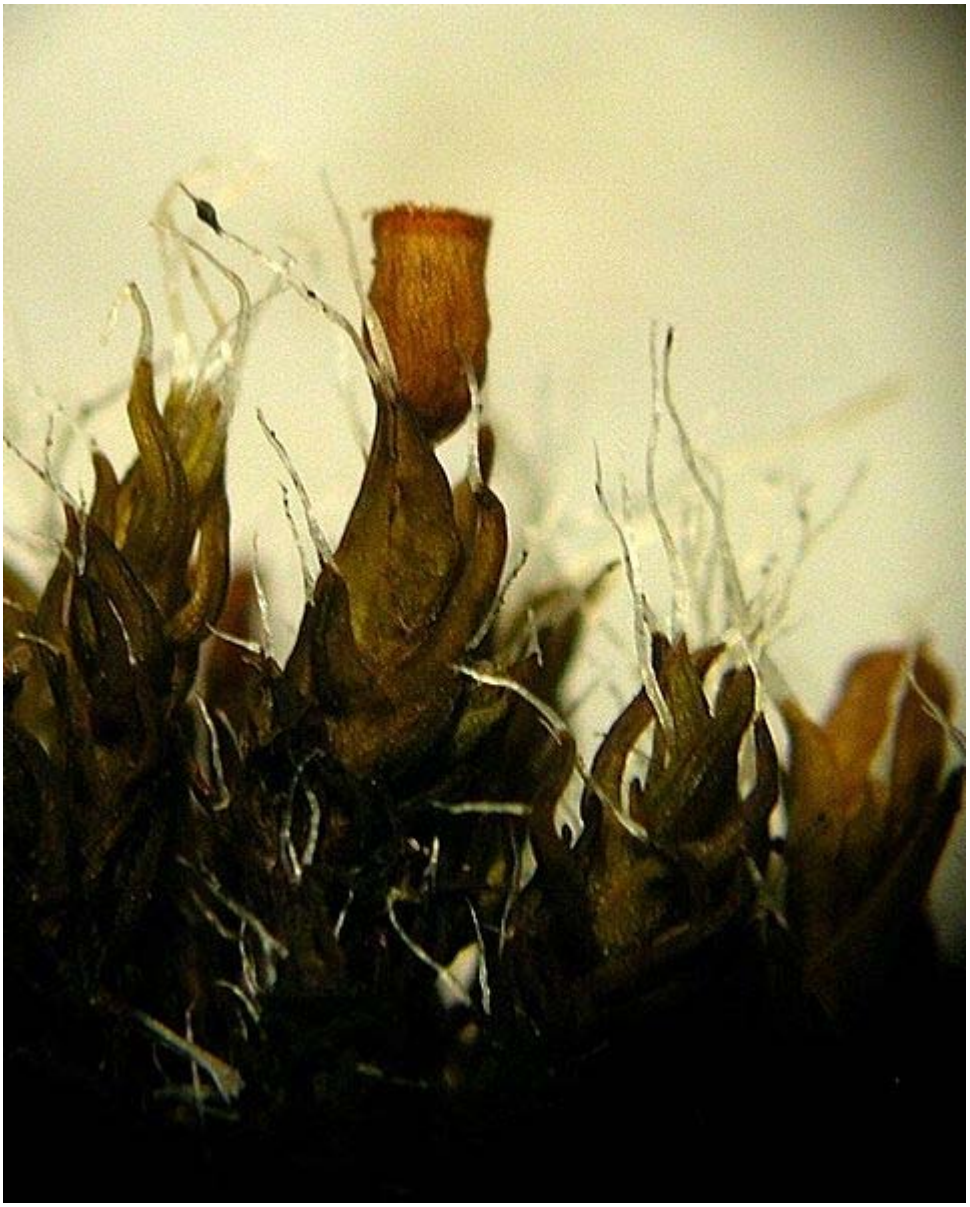
differentiation of an axis or stem, leaves or phylloids and multicellular colorless branched rhizoids with oblique septa.

These are primitive multicellular, autotrophic, shade loving, amphibious plants. They reproduce by spore formation. They have no vascular system. Root like structures called rhizoids are present. They show alternation of generation i.e. the gametophytic stage alternates with the sporophytic stage.

Chapter- 10

Grimmia

Grimmia dissimulata habit dry 2009-01-29



Grimmia macroperichaetialis perichaetial leaves moist 2008-11-24

Grimmia maido habit moist 2008-11-08

Grimmia torenii habit dry 2008-11-07

***Grimmia* (Hedw. 1801)** is a genus of mosses (Bryophyta), originally named by Jakob Friedrich Ehrhart in honour of Johann Friedrich Carl Grimm, a physician and botanist from Gotha, Germany.

Geographic distribution

Although predominantly occurring in the moderate zones, representatives of the cosmopolitan genus *Grimmia* may be found in all parts of the world, from Alaska to the most southern point of Chile, and from Siberia to South Africa, though in tropic regions, e.g. Hawaii and Indonesia, *Grimmia* species only occur high up in the mountains.

Identification

Grimmia is a notoriously difficult genus in terms of identification, and in the majority of herbaria a considerable number of species was found misidentified. The American bryologist Geneva Sayre (1911–1992), who worked for many years on a monograph of the North American *Grimmias*, indicated in an original way these difficulties, as she said: "it contains an ambigua, a varia, a decipiens, a controversa, a revisa and at least two anomalas" (Richards, 1993).

Publications

In the **Index Muscorum** (Wijk et al. 1962), the genus *Grimmia* is represented with 800 names of published species. As since **Loeske** (1930), no revision of the European species had been carried out.

The Dutch bryologist **H.C. Greven** started in 1990 with *Grimmia* fieldwork and a revision of the *Grimmia* collections from important European **herbaria**. The results were published in ***Grimmia* Hedw. (Grimmiaceae, Musci) in Europe** (Greven 1995).

After examining the *Grimmia* collections from **erbaria** in North- and South America, South Africa, Australia and New Zealand, and about 50 *Grimmia* collecting trips in all continents, **Grimmias of the World** was published (Greven 2003). An important contribution was the revision of ***Grimmia* in North America** (Hastings & Greven 2007).

In the past decades, some more bryologists became interested in the genus *Grimmia*. **Muñoz** (1999) published a **herbaria** revision of *Grimmia* in Latin America. And **Maier** (2002a) studied **herbaria** specimens of *Grimmia* from the Himalaya.

Latest discovered species

In the past 15 years (1996 to 2010), the following *Grimmia* species have been discovered and described:

1. *Grimmia maido* (Greven 1996)
2. *Grimmia macroperichaetialis* (Greven 1998)

3. *Grimmia ochyriana* (Muñoz 1998)
4. *Grimmia wilsonii* (Greven 1998)
5. *Grimmia mexicana* (Greven 1999)
6. *Grimmia molesta* (Muñoz 1999)
7. *Grimmia indica* (Goffinet & Greven 2000)
8. *Grimmia dissimulata* (Maier 2002b)
9. *Grimmia nevadensis* (Greven 2002)
10. *Grimmia serrana* (Muñoz, Shevock & Toren 2002)
11. *Grimmia lesherae* (Greven 2003)
12. *Grimmia mauiensis* (Greven 2003)
13. *Grimmia maunakeaensis* (Greven 2003)
14. *Grimmia shastae* (Greven 2003)
15. *Grimmia milleri* (Hastings & Greven 2007)
16. *Grimmia torenii* (Hastings 2008)
17. *Grimmia texicana* (Greven 2010)

Chapter- 11

Hylocomium Splendens and Hypnum Cupressiforme

Hylocomium splendens

Glittering Wood-moss

Scientific classification

Kingdom:	Plantae
Division:	Bryophyta
Class:	Bryopsida
Subclass:	Bryidae
Order:	Hypnales
Family:	Hylocomiaceae
Genus:	*Hylocomium*
Species:	***H. splendens***

Binomial name

Hylocomium splendens

Hylocomium splendens, commonly known as **Glittering Wood-moss**, **Stair-step Moss** and **Mountain Fern Moss**, is a perennial clonal moss with a widespread distribution in Northern Hemisphere boreal forests. It is commonly found in Europe, Russia, Alaska and Canada, where it is often the most abundant moss species. It also grows in the Arctic

tundra and further south at higher elevations in, for example, northern California, western Sichuan, East Africa, Australia, New Zealand and the West Indies. In Scotland it is a characteristic species of the Caledonian Forest. Under the UK's national vegetation classification system, pinewood community W18 is named as "Pinus sylvestris-Hylocomium splendens woodland", indicating its significance in this ecosystem.

Morphology

Close up taken in Mount Baker-Snoqualmie National Forest

It is generally olive green, yellowish or reddish green in colour, with reddish stems and branches. These often form branches up to 20 cm. long, with current year's growth starting from near the middle of the previous year's branch. This produces feathery fronds

in steps. It is possible to estimate the age of a plant by counting the steps - a new level being produced each year. This form of growth enables the species to "climb" over other mosses and forest debris that falls on it. It is shade-loving, grows in soil and humus and on decaying wood and often forms mats with living parts growing on top of older, dead or dying sections. Further south, the plants are larger with several steps; further north, in the arctic tundra, the plants are smaller with few steps.

Ecology

Occurring widely in the boreal forests, this plant is often found on forest floors even in relatively harsh northern latitudes. In Canada, for example, according to C. Michael Hogan the Black Spruce/Feathermoss climax forest often occurs with moderately dense canopy featuring a forest floor of feathermosses that include *H. splendens*, *Pleurozium schreberi* and *Ptilium crista-castrensis*.

Use

The species has a commercial use in floral exhibitions and for lining fruit and vegetable storage boxes. In the past it was utilised as a floor covering for dirt floors and in Alaska and northern Canada it is still used for filling the gaps between the logs in log cabins. It has anti-bacterial qualities and may also contain anti-tumour agents.

Hypnum cupressiforme

Hypnum cupressiforme

Scientific classification

Kingdom:	Plantae
Division:	Bryophyta

Class:	Bryopsida
Subclass:	Bryidae
Order:	Hypnales
Family:	Hypnaceae
Genus:	*Hypnum*
Species:	***H. cupressiforme***

Binomial name

Hypnum cupressiforme

Hypnum cupressiforme (**cypress-leaved plait-moss** or **hypnum moss**) is a common and widespread species of moss belonging to the genus *Hypnum*. It is found in all continents except Antarctica and occurs in a wide variety of habitats and climatic zones. It typically grows on tree trunks, logs, walls, rocks and other surfaces. It prefers acidic environments and is fairly tolerant of pollution. It was formerly used as a filling for pillows and mattresses; the association with sleep is the origin of the genus name *Hypnum* (from Greek *Hypnos*).

Capsules

It is a small to medium-sized moss about 2-10 cm long. It is pleurocarpous, having prostrate, creeping stems which form smooth, dense mats. The stems are branched and covered in overlapping leaves giving the impression of a cypress tree. The stem leaves are long and thin measuring 1.0-2.1 mm by 0.3-0.6 mm. They are concave and sickle-shaped, tapering towards the tip. The branch leaves are smaller and narrower than those on the stems. The moss produces short, cylindrical and slightly curved capsules which contain the spores. The capsules are 1.7-2.4 mm long and have a lid-like operculum measuring 0.6-0.9 mm. They are borne on reddish-brown stalks which are 1-2.5 cm long. The moss is dioicous, having separate male and female plants. *Hypnum cupressiforme* is a highly variable species and numerous varieties have been described.

Chapter- 12

Java Moss and Meesia Triquetra

Java moss

Java Moss

Scientific classification
Kingdom: Plantae
Division: Bryophyta
Class: Bryopsida
Subclass: Bryidae
Order: Hypnales
Family: Hypnaceae

Java Moss is a moss belonging to the Hypnaceae family. Native to Southeast Asia, it is commonly used in freshwater aquariums. It attaches to rocks, roots, and driftwood. The identity of this well-known plant is not resolved; formerly thought to be ***Vesicularia dubyana*** (Brotherus, 1908), it may actually be ***Taxiphyllum barbieri***.

Java Moss does not require any special attention. It accepts all kind of waters, even weakly brackish, and all kind of light qualities. It grows best at 70 to 75 degrees Fahrenheit (21 to 24 degrees Celsius), but can live in temperatures of up to 85 to 90 °F (29 to 32 °C). It is a low light plant and makes a great foreground plant. In aquariums it

should be planted where there is good water current because debris gets stuck on it easily and gives it a brown fuzzy appearance. Due to its clinging nature Java Moss can also be made into a moss wall. This can be accomplished by folding a net and spreading the moss evenly across it. Then, the net can be secured together by polyester strings, and held on the aquarium wall by using suction cups. It is a slow starter until it has established itself.

It is especially popular among aquarists raising fry (baby fish) and tadpoles, to protect them from cannibalistic adults. Java Moss can also provide food for the newly formed fry, which can be challenging to feed. Some shrimp like to tear the miniature leaves off it to eat.

Java Moss can be easily propagated via division. It is suitable for both aquariums and vivariums.

Meesia triquetra

Threeranked Humpmoss
Conservation status

Secure (NatureServe)

Scientific classification	
Kingdom:	Plantae
Division:	Bryophyta
Class:	Bryopsida
Subclass:	Bryidae
Order:	Splachnales
Family:	Meesiaceae
Genus:	*Meesia*
Species:	***M. triquetra***

Binomial name
Meesia triquetra (Richt.) Ångstr.

Threeranked humpmoss (***Meesia triquetra***), is a moss that occurs all around the northern hemisphere in higher latitudes.

Technical description

Meesia triqueta grows in small tufts or cushions. The **plants**, often large, are acrocarpous and dioicous. In color they are dark-green to grass-green above, occasionally red-brown

below due to dense rhizoids. The plant's **stems** are not branched or little branched, pale-brown to yellow-brown, closely foliate, and 2–14 cm high. Its **leaves** are decurrent, squarrose (spreading) when moist, triangular to ovate to lanceolate, somewhat crispate (contorted), 2–3½ mm long, and tristichous (in three obvious ranks). The leaf margins are sharply serrate or denticulate to the base or nearly so, plane or sometimes recurved in the middle of the leaf. The costa is relatively narrow (less than 1/5 the width of the leaf base), subpercurrent to percurrent, gradually tapering at distal end. The leaf's apex is acute to acuminate (sharply pointed). The lamina is unistratose throughout. Meesia triqueta's **perigonia** are terminal in discoid heads. The **seta** is straight and smooth, brown to yellow-brown, and very long (4–10 cm). The **capsule** is asymmetrical, somewhat pyriform, 2¾–5½ mm long including the neck; the hypophysis (neck) is long (comprising up to ½ of capsule length), moderately well-defined, not much wrinkled when dry; the urn is oblong to short-cylindric, arcuate and asymmetric, brown to yellow-brown, up to 4 mm long, and when dry, wrinkled but not regularly sulcate. The operculum is short-conic; the endostome cilia are often rather well-developed. The plant's **spores** are finely papillose.

Distribution, habitat, and ecology

This species has a circumboreal distribution: it is found in Northern Europe, northern Asia, Greenland, Canada, and the northern U.S. Some discoveries have been reported from Oceania.

These mosses occur in wetland sites, specifically, within wet woods in the wettest portions of what are called "extreme rich fens" (*i.e.*, fens having surface waters with high pH and calcium concentrations). Montagnes describes this species as a "rich fen indicator of high fidelity." Associates include *Scorpidium* spp. and *Drepanocladus revolvens*.

The fire ecology of this plant is not known; however, fens rarely burn. Excess soot from a nearby fire, however, might negatively affect habitat quality. Fire return intervals in conifer bogs, a somewhat similar mire-type habitat, are estimated to be about once every 150-200 years. Fire does significant damage to peat, but the bog must be dry (as during a drought year) in order to burn; typically, bogs are not dry enough.

Conservation status and threats

U.S. Forest Service Pacific Southwest Region Sensitive Species.

California Native Plant Society List 4.2

NatureServe California State Rank: S2.2; Global Rank: G5

Fens are delicate habitats susceptible to impacts from livestock grazing, hydrologic alteration, construction and continued use of roads, and peat mining. Rich fen habitats are especially susceptible to modification. The surface water chemistry of rich fens is

sensitive to climatic and anthropogenic influences. This species has reached near extinction in Europe.

Field identification

M. triquetra is easily recognized by its distinct three-ranked leaf arrangement and for being dioicous. It may be distinguished from *M. uliginosa* by its squarrose leaves; narrow costa relative to the size of the leaf base; serrate, planar leaf margins; and acute leaf tips. In contrast, *M. uliginosa* a wide (up to 1/3 of the leaf base) costa, entire, revolute leaf margins, and blunt apices. Other *Meesia* species also have blunt apices.

Chapter- 13

Physcomitrella Patens and Platyhypnidium Riparioides

Physcomitrella patens

Physcomitrella patens

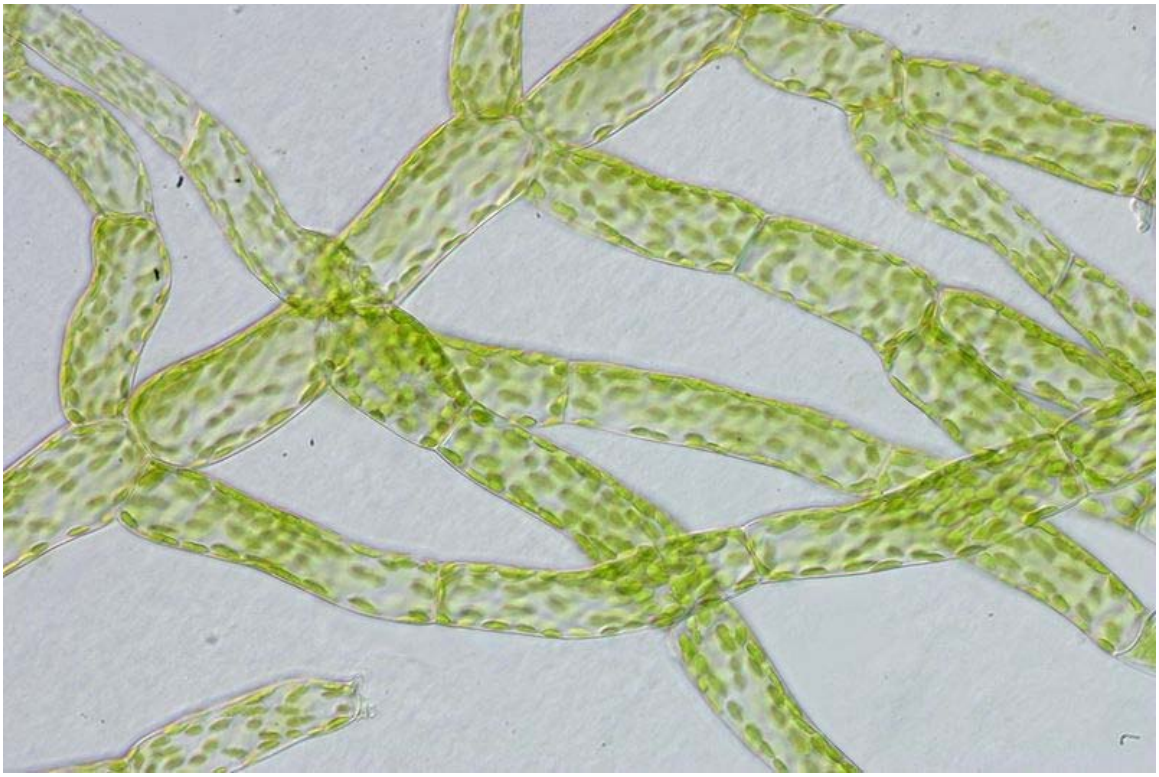
Scientific classification	
Kingdom:	Plantae
Division:	Bryophyta
Class:	Bryopsida
Subclass:	Funariidae
Order:	Funariales
Family:	Funariaceae
Genus:	*Physcomitrella*

Binomial name

Physcomitrella patens
(Hedw.) Bruch & Schimp.

Physcomitrella patens is a moss (Bryophyta) used as a model organism for studies on plant evolution, development and physiology.

Model organism



Protonema cells of *Physcomitrella patens*

Mosses share fundamental genetic and physiological processes with vascular plants, although the two lineages diverged early in land plant evolution. A comparative study between modern representatives of the two lines can give an insight into the evolution of the mechanisms behind the complexity of modern plants. It is in this context that *Physcomitrella patens* is used as a model organism.

Physcomitrella patens is one of a few known multicellular organisms with highly efficient homologous recombination. Basically, this means that researchers are able to target an exogenous DNA sequence to a specific genomic position (a technique called gene targeting) to create knockout mosses. This approach is called reverse genetics and it is a powerful and sensitive tool to study the function of genes and, when combined with studies in plants like *Arabidopsis thaliana*, can help to unravel major molecular trends of plant evolution.

In addition, *P. patens* is increasingly used in biotechnology. Prominent examples are the identification of moss genes with implications for crop improvement or human health and the safe production of complex biopharmaceuticals in the moss bioreactor, developed by Ralf Reski and his co-workers.

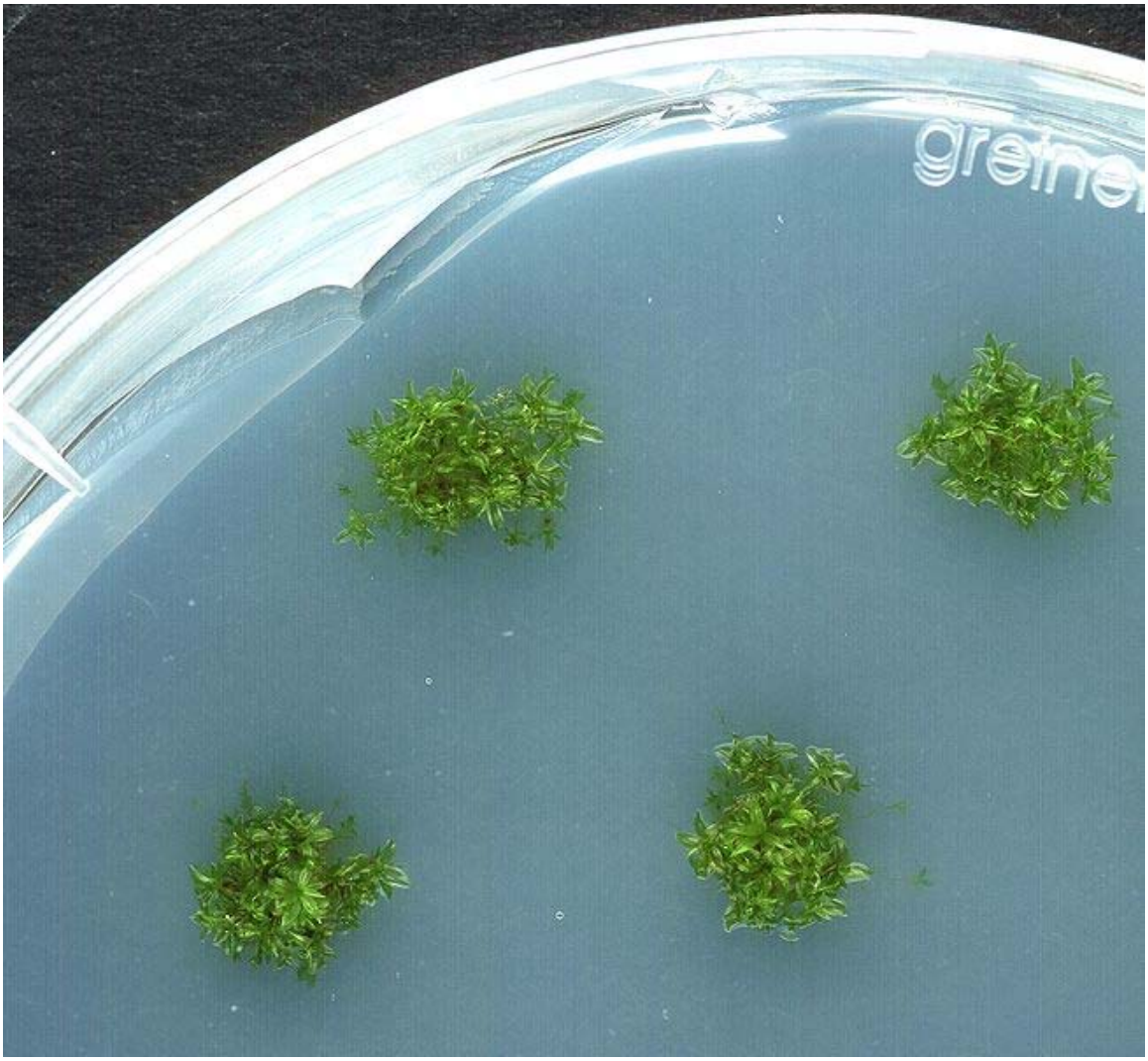
The genome of *Physcomitrella patens*, with about 500 megabase pairs organized into 27 chromosomes, was completely sequenced in 2006.

Physcomitrella ecotypes, mutants, and transgenics are stored and made freely available to the scientific community by the International Moss Stock Center (IMSC). The accession numbers given by the IMSC can be used for publications to ensure safe deposit of newly described moss materials.

Moss photobioreactor with *Physcomitrella patens*

Life cycle

Cleistocarpous sporophyte of the moss *Physcomitrella patens*



Physcomitrella patens plants growing axenically in vitro on agar plates (Petri dish, 9 cm diameter)

Like all mosses, the life cycle of *Physcomitrella patens* is characterized by an alternation of two generations: 1) a haploid gametophyte that produces gametes and 2) a diploid sporophyte where haploid spores are produced.

A spore develops into a filamentous structure called protonema, composed of two types of cells – chloronema with large and numerous chloroplasts and caulonema with very fast growth. Protonema filaments grow exclusively by tip growth of their apical cells and can originate side branches from subapical cells. Some side branch initial cells can differentiate into buds rather than side branches. These buds give rise to gametophores (0.5 – 5 mm), more complex structures bearing leaf-like structures, rhizoids and the sexual organs: female archegonia and male antheridia. *Physcomitrella patens* is monoicous, meaning that male and female organs are produced in the same plant. If water is available flagellate sperm cells can swim from the antheridia to an archegonium and

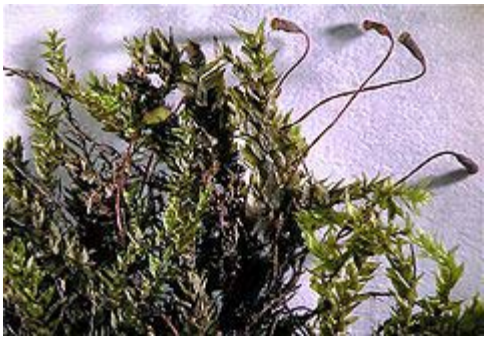
fertilize the egg within. The resulting diploid zygote originates a sporophyte composed of a foot, seta and capsule, where thousands of haploid spores are produced by meiosis.

Distribution

Physcomitrella patens is widely distributed in the northern hemisphere.

Platyhypnidium riparioides

Platyhypnidium riparioides



Plants of *Platyhypnidium riparioides*

Conservation status

Apparently Secure (NatureServe)

Scientific classification	
Kingdom:	Plantae
Division:	Bryophyta
Class:	Bryopsida
Order:	Hypnales
Family:	Brachytheciaceae
Genus:	*Platyhypnidium*
Species:	***P. riparioides***

Binomial name
Platyhypnidium riparioides Hedw.

Platyhypnidium riparioides (Long-beaked Water Feather-moss) is a species of aquatic moss commonly found in many regions. This species is among the largest aquatic mosses

growing up to 15 cm long. *P. riparioides* grows in a procumbent or pendulous fashion along rocks and tree roots and may form extensive lax mats of many intermingled plants. It is widely distributed South of the Arctic and can grow abundantly in suitable areas.

Description

Platyhypnidium ripariodes is among the larger northern hemisphere mosses with leaves up to 8mm long and plants growing up to 15 cm long. In the UK, plants commonly produce calyptra with relatively long curving lids. The leaf tip is acute, leaf margins are plane, slightly denticulate towards tip, mid-leaf cells are large, costa or the central stork of the leaf extends nearly to leaf tip. The growth form is procumbent but small, young plants can attach themselves closely to rocks and appear flattened.

Identification

Platyhypnidium ripariodes diagnostic features include its comparatively large size, up to 15 cm long, large leaf size up to 8 mm with elongated mid-leaf cells. Capsules are abundant and frequently produced and feature long curving lid. In the UK, mosses growing in similar habitats and maybe confused with P. ripariodes include aquatic *Brachythecium* genus and *Leptodictyum riparium*. All these mosses are platycarpus, have a single nerve per leaf and overlap in size but can be separate by leaf shape, cell structure and growth form.

Distribution

Wide global distribution found South of the Arctic polar region in flowing freshwater mainly in Northern Hemisphere. Found commonly in the British Isles.

Chapter- 14

Polytrichum and Polytrichum Commune

Polytrichum

Polytrichum

Male gametophytes of *Polytrichum strictum* bearing antheridia.

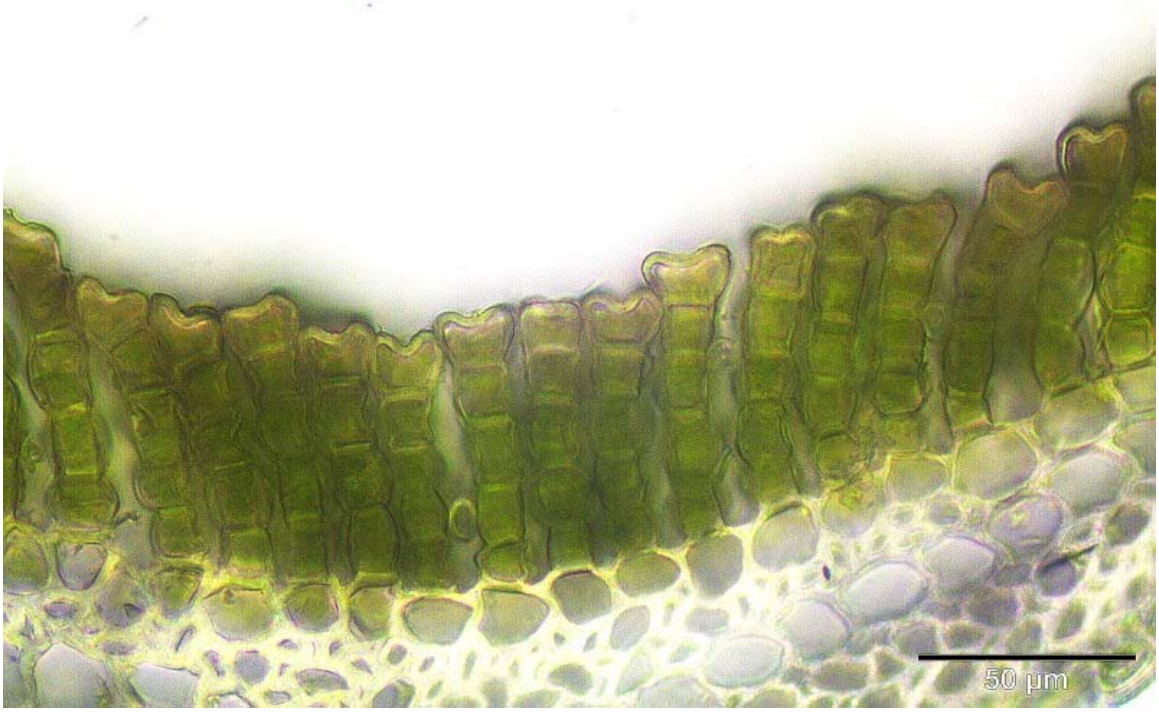
Scientific classification	
Kingdom:	Plantae
Division:	Bryophyta
Class:	Polytrichopsida
Subclass:	Polytrichidae
Order:	Polytrichales
Family:	Polytrichaceae
Genus:	***Polytrichum*** Hedw.

Polytrichum is a genus of mosses, commonly called **haircap moss** or **hair moss**, which contains approximately 70 species that cover a cosmopolitan distribution. Less common

vernacular names include **bird wheat** and **pigeon wheat**. The genus has a number of closely related sporophytic characters. The scientific name is derived from the Ancient Greek words *polys*, meaning "many", and *thrix*, meaning "hair". This name was used in ancient times to refer to plants with fine, hairlike parts, including mosses, but this application specifically refers to the hairy calyptras found on young sporophytes. There are two major sections of Polytrichum species. The first, section *Polytrichum*, has narrow, toothed, and relatively erect leaf margins. The other, section *Juniperifolia*, has broad, entire, and sharply inflexed leaf margins that enclose the lamellae on the upper leaf surface.

Physiology

Mosses in the genus *Polytrichum* are endohydric, meaning water must be conducted from the base of the plant. While mosses are considered non-vascular plants, those of *Polytrichum* show clear differentiation of water conducting tissue. One of these water conducting tissues is termed the *hadrom*, which makes up the central cylinder of stem tissue. It consists of cells with a relatively wide diameter called *hydroids*, which conduct water. This tissue is analogous to xylem in higher plants. The other tissue is called *leptom*, which surrounds the hadrom and contains smaller cells. This tissue is, on the other hand, analogous to phloem.



Cross section of a leaf of *Polytrichum commune* showing parallel photosynthetic lamellae at 400x magnification. The green cells contain chloroplasts.

Another characteristic feature of the genus is its parallel photosynthetic lamellae on the upper surfaces of the leaves. Most mosses simply have a single plate of cells on the leaf surface, but those of *Polytrichum* have more highly differentiated photosynthetic tissue. This is an example of a xeromorphic adaption, an adaptation for dry conditions. Moist air is trapped in between the rows of lamellae, while the larger terminal cells act to contain moisture and protect the photosynthetic cells. This minimises water loss as relatively little tissue is directly exposed to the environment, but allows for enough gas exchange for photosynthesis to take place. The microenvironment between the lamellae can host a number of microscopic organisms such as parasitic fungi and rotifers. Additionally, the leaves will curve and then twist around the stem when conditions become too dry, this being another xeromorphic adaptation. It is speculated that the teeth along the leaf's edge may aid in this process, or perhaps also that they help discourage small invertebrates from attacking the leaves.

Classification

The genus *Polytrichastrum* was separated from *Polytrichum* in 1971 based on the structure of the peristome (which controls spore release). However, molecular and morphological data from 2010 support moving some species back into *Polytrichum*.

Species

- *Polytrichum appalachianum*
- *Polytrichum alpinum*
- *Polytrichum commune*
- *Polytrichum formosum*
- *Polytrichum hyperboreum*
- *Polytrichum juniperinum*
- *Polytrichum longisetum*
- *Polytrichum lyallii*
- *Polytrichum ohioense*
- *Polytrichum pallidisetum*
- *Polytrichum papillatum*
- *Polytrichum piliferum*
- *Polytrichum sexangulare*
- *Polytrichum sphaerothecium*
- *Polytrichum strictum*
- *Polytrichum swartzii*

Polytrichum commune

Polytrichum commune

Plants of *Polytrichum commune*

Conservation status

Secure (NatureServe)

Scientific classification	
Kingdom:	Plantae
Division:	Bryophyta
Class:	Polytrichopsida
Subclass:	Polytrichidae
Order:	Polytrichales
Family:	Polytrichaceae
Genus:	*Polytrichum*
Species:	***P. commune***

Binomial name

Polytrichum commune
Hedw.

Polytrichum commune (**Common Haircap Moss**, **Common Hair Moss**, or **Great Goldilocks**) is a species of moss found in many regions with high humidity and rainfall. The species can be exceptionally tall for a moss with stems often exceeding 30 cm (12 inches) though rarely reaching 70 cm (28 inches), but it is most commonly found at shorter lengths of 5 to 10 cm (2 to 4 inches). It is widely distributed throughout temperate and boreal latitudes in the Northern Hemisphere and also found in Mexico, several Pacific Islands including New Zealand, and also in Australia. It typically grows in bogs, wet heathland and along forest streams.

There are about 15,000 species of moss, but only four of the easiest-to-grow — fern, hair cap, rock cap and cushion — are commonly sold commercially and suitable for use as ground cover in residential lawns and gardens.(NYTimes 2008 Moss Makes a Lush, No-Care Lawn)

Description

Polytrichum commune is a medium to large moss. It is dark green in colour, but becomes brownish with age. The stems can occur in either loose or quite dense tufts, often forming extensive colonies. The stems are most typically found at lengths of 5 to 10 cm, but can be as short as 2 cm or as long as 70 cm. They range in stiffness from erect to decumbent (i.e. reclining) and are usually unbranched, though in rare cases they may be forked. The leaves occur densely to rather distantly, and bracts are present proximally.

The leaves typically measure 6 to 8 mm in length, but may be up to 12 mm long. When dry they are erect, but when moist they are sinuous with recurved tips and are generally spreading to broadly recurved, or sharply recurved from the base. The leaf sheath is oblong to elliptic in outline, forming an involute (i.e. with inward rolling margins) tube and clasping the stem. This sheath is typically golden yellow and shiny, and it is abruptly contracted to the narrowly lanceolate blade. Using a microscope, the marginal lamina can be seen to be level or erect, narrow, and typically 2 to 3 cells wide, though sometimes as many as 7 cells wide. It is toothed from the base of the blade up to the apex, with the teeth being unicellular and embedded in the margin. The costa, or central stalk of the leaf, is toothed on the underside near the apex, and is excurrent, meaning it extends beyond the end of the apex, ending in a short, rough awn.

Cross section of a leaf showing parallel lamellae (perpendicular to leaf surface) at 125x magnification

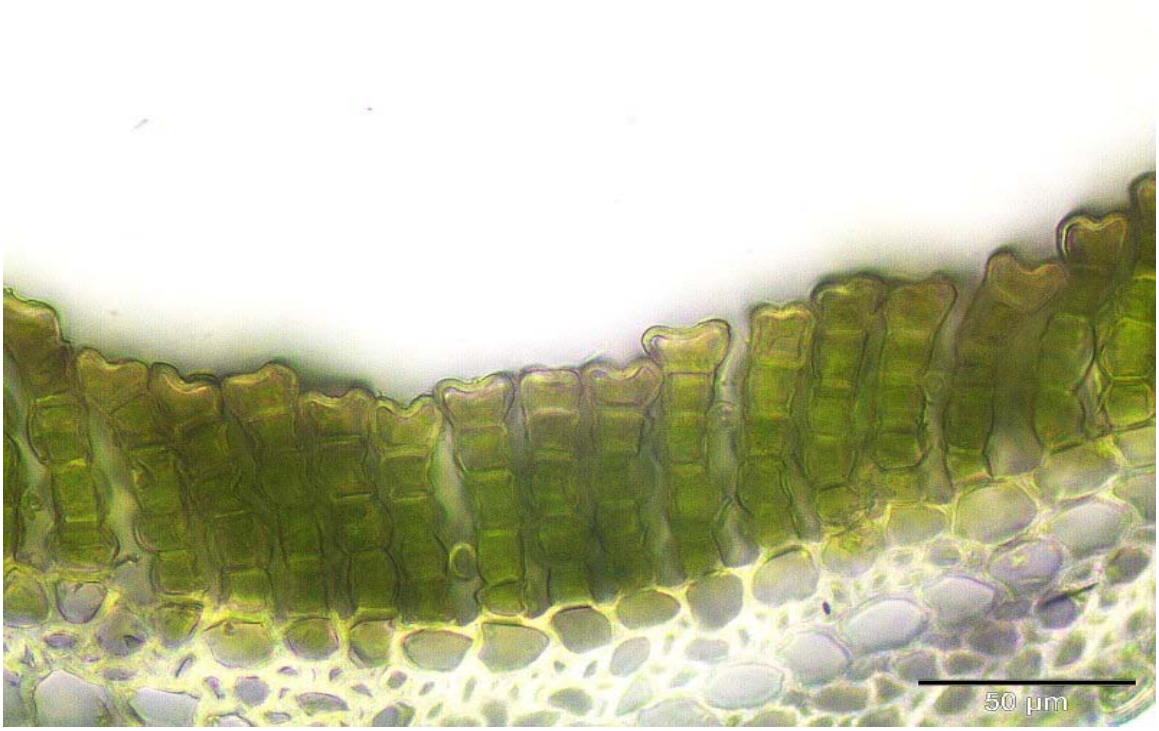
The lamellae, ridges of cells that run along the leaf surface, are crenulate (i.e. with small rounded teeth) in profile and are 5 to 9 cells high. Their margins are distinctly grooved with 2 rows of paired, projecting knobs. The marginal cells, when observed in section, may be narrow, but are more typically enlarged and wider than those beneath. They are retuse (i.e. with a rounded apex with a central shallow notch) to deeply notched, and in rare cases are divided by a vertical partition. These cells are smooth and brownish in colour and have relatively thick cell walls. The sheath cells measure 60 to 90 µm long by 10 to 13 µm wide. These cells may be elongated rectangles or strongly linear structures up to 20 times long as wide. They become narrower toward the margins. Marginal lamina cells are 10 to 15 µm wide and are subquadrate (i.e. nearly square).

Close-up of capsules (after shedding of calyptra)

The plants are sexually dioicous. The leaves of the perichaetium have a long sheath with a scarious (i.e. membranous) margin, while the blades themselves are greatly reduced, gradually narrowing to a finely acuminate tip. These blades have toothed margins, are denticulate to subentire in outline, roughened to almost smooth, and have a costa that is excurrent. The seta, or capsule stalk, is 5 to 9 cm long, and is stout and yellowish to reddish brown in colour. The capsule is 3 to 6 mm long, slightly rectangular to cubic in shape, and brown to dark reddish brown in colour. It is sharply 4 winged, inclined to horizontal, and glaucous when fresh. The peristome measures 250 µm, is pale in colour and has 64 teeth. The calyptra is golden yellow to brownish and completely envelops the capsule. The spores measure 5 to 8 µm, but may be up to 12 µm.

Physiology

Polytrichum commune is an endohydric moss, meaning water must be conducted from the base of the plant. While mosses are considered non-vascular plants, *Polytrichum commune* shows clear differentiation of water conducting tissue. One of these water conducting tissues is termed the *hadrom*, which makes up the central cylinder of stem tissue. It consists of cells with a relatively wide diameter called *hydroids*, which conduct water. This tissue is analogous to xylem in higher plants. The other tissue is called *leptom*, which surround the hadrom and contains smaller cells. This tissue is, on the other hand, analogous to phloem. When these two tissue types are taken into account along with the species' exceptional height, it becomes clear that common haircap moss is quite a unique moss considering that the majority of species show little differentiation of conducting tissue and are restricted to much smaller stem lengths.



Cross section of a leaf showing parallel photosynthetic lamellae at 400x magnification. The green cells contain chloroplasts.

Another characteristic feature of the species (and the genus) is its parallel photosynthetic lamellae on the upper surfaces of the leaves. Most mosses simply have a single plate of cells on the leaf surface, but common haircap moss has more highly differentiated photosynthetic tissue. This is an example of a xeromorphic adaption, an adaptation for dry conditions. Moist air is trapped in between the rows of lamellae, while the larger terminal cells act to contain moisture and protect the photosynthetic cells. This minimises water loss as relatively little tissue is directly exposed to the environment, but allows for enough gas exchange for photosynthesis to take place. The microenvironment between the lamellae can host a number of microscopic organisms such as parasitic fungi and rotifers. Additionally, the leaves will curve and then twist around the stem when conditions become too dry, this being another xeromorphic adaptation. It is speculated that the teeth along the leaf's edge may aid in this process, or perhaps also that they help discourage small invertebrates from attacking the leaves.

Variety

- Polytrichum commune var. commune
- Polytrichum commune var. jensenii
- Polytrichum commune var. perigoniale

Chapter- 15

Marchantiophyta

Liverworts
Temporal range: 472–0 Ma
Mid-Ordovician to recent

"Hepaticae" from Ernst Haeckel's *Kunstformen der Natur*, 1904

Scientific classification

Kingdom: Plantae

Division: **Marchantiophyta** Stotler & Stotl.-Crand., 1977 emend. 2000

Classes and Orders

Haplomitriopsida Stotler & Stotl.-Crand.

- Haplomitriales (Calobryales)
- Treubiales

Jungermanniopsida Stotler & Stotl.-Crand.

- Metzgeriales (simple thalloids)
- Jungermanniales (leafy liverworts)

Marchantiopsida Stotler & Stotl.-Crand.

- Blasiales
- Sphaerocarpales (bottle liverworts)
- Marchantiales (complex thalloids)

The **Marchantiophyta** are a division of bryophyte plants commonly referred to as **hepatics** or **liverworts**. Like other bryophytes, they have a gametophyte-dominant life cycle, in which cells of the plant carry only a single set of genetic information.

It is estimated that there are 6000 to 8000 species of liverworts, though when neotropical regions are better studied this number may approach 10,000. Some of the more familiar species grow as a flattened leafless thallus, but most species are leafy with a form very much like a flattened moss. Leafy species can be distinguished from the apparently similar mosses on the basis of a number of features, including their single-celled rhizoids. Leafy liverworts also differ from most (but not all) mosses in that their leaves never have a costa (present in many mosses) and may bear marginal cilia (very rare in mosses). Other differences are not universal for all mosses and liverworts, but the occurrence of leaves arranged in three ranks, the presence of deep lobes or segmented leaves, or a lack of clearly differentiated stem and leaves all point to the plant being a liverwort.

Liverworts are typically small, usually from 2–20 mm wide with individual plants less than 10 cm long, and are therefore often overlooked. However, certain species may cover large patches of ground, rocks, trees or any other reasonably firm substrate on which they occur. They are distributed globally in almost every available habitat, most often in humid locations although there are desert and arctic species as well. Some species can be a nuisance in shady green-houses or a weed in gardens.

Physical characteristics

Description

Most liverworts are small, usually from 2–20 millimetres (0.08–0.8 in) wide with individual plants less than 10 centimetres (4 in) long, so they are often overlooked. The most familiar liverworts consist of a prostrate, flattened, ribbon-like or branching structure called a thallus (plant body); these liverworts are termed *thallose liverworts*. However, most liverworts produce flattened stems with overlapping scales or leaves in two or more ranks, the middle rank is often conspicuously different from the outer ranks; these are called *leafy liverworts* or *scale liverworts.*

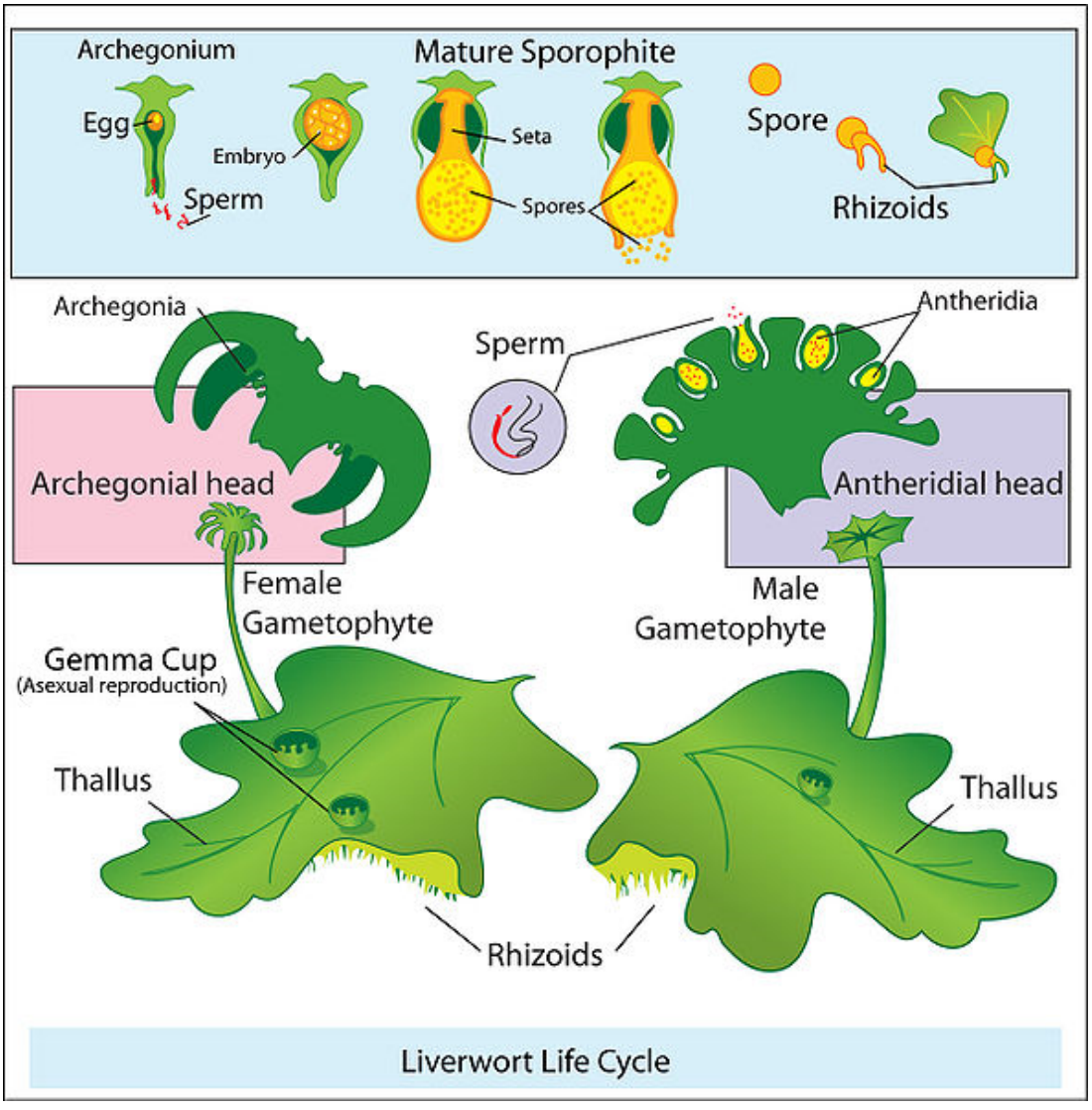
A thallose liverwort, *Lunularia cruciata*

Liverworts can most reliably be distinguished from the apparently similar mosses by their single-celled rhizoids. Other differences are not universal for all mosses and all liverworts; but the lack of clearly differentiated stem and leaves in thallose species, or in leafy species the presence of deeply lobed or segmented leaves and the presence of leaves arranged in three ranks, all point to the plant being a liverwort. In addition, 90% of liverworts contain oil bodies in at least some of their cells, and these cellular structures are absent from most other bryophytes and from all vascular plants. The overall physical similarity of some mosses and leafy liverworts means that confirmation of the

identification of some groups can be performed with certainty only with the aid of microscopy or an experienced bryologist.

Liverworts have a gametophyte-dominant life cycle, with the sporophyte dependent on the gametophyte. Cells in a typical liverwort plant each contain only a single set of genetic information, so the plant's cells are haploid for the majority of its life cycle. This contrasts sharply with the pattern exhibited by nearly all animals and by most other plants. In the more familiar seed plants, the haploid generation is represented only by the tiny pollen and the ovule, while the diploid generation is the familiar tree or other plant. Another unusual feature of the liverwort life cycle is that sporophytes (i.e. the diploid body) are very short-lived, withering away not long after releasing spores. Even in other bryophytes, the sporophyte is persistent and disperses spores over an extended period.

Life cycle



Life cycle of a typical liverwort

The life of a liverwort starts from the germination of a haploid spore to produce a protonema, which is either a mass of thread-like filaments or else a flattened thallus. The protonema is a transitory stage in the life of a liverwort, from which will grow the mature gametophore ("gamete-bearer") plant that produces the sex organs. The male organs are known as antheridia (*singular:* antheridium) and produce the sperm cells. Clusters of antheridia are enclosed by a protective layer of cells called the **perigonium** (*plural:* perigonia). As in other land plants, the female organs are known as archegonia (*singular:* archegonium) and are protected by the thin surrounding **perichaetum** (*plural:* perichaeta). Each archegonium has a slender hollow tube, the "neck", down which the sperm swim to reach the egg cell.

Liverwort species may be either dioicous or monoicous. In dioicious liverworts, female and male sex organs are borne on different and separate gametophyte plants. In monoicious liverworts, the two kinds of reproductive structures are borne on different branches of the same plant. In either case, the sperm must move from the antheridia where they are produced to the archegonium where the eggs are held. The sperm of liverworts is *biflagellate*, i.e. they have two tail-like flagellae that enable them to swim short distances, provided that at least a thin film of water is present. Their journey may be assisted by the splashing of raindrops. In 2008, Japanese researchers discovered that some liverworts are able to fire sperm-containing water up to 15 cm in the air, enabling them to fertilize female plants growing more than a metre from the nearest male.

When sperm reach the archegonia, fertilisation occurs, leading to the production of a diploid sporophyte. After fertilisation, the immature sporophyte within the archegonium develops three distinct regions: (1) a **foot**, which both anchors the sporophyte in place and receives nutrients from its "mother" plant, (2) a spherical or ellipsoidal **capsule**, inside which the spores will be produced for dispersing to new locations, and (3) a **seta** (stalk) which lies between the other two regions and connects them. When the sporophyte has developed all three regions, the seta elongates, pushing its way out of the archegonium and rupturing it. While the foot remains anchored within the parent plant, the capsule is forced out by the seta and is extended away from the plant and into the air. Within the capsule, cells divide to produce both elater cells and spore-producing cells. The elaters are spring-like, and will push open the wall of the capsule to scatter themselves when the capsule bursts. The spore-producing cells will undergo meiosis to form haploid spores to disperse, upon which point the life cycle can start again.

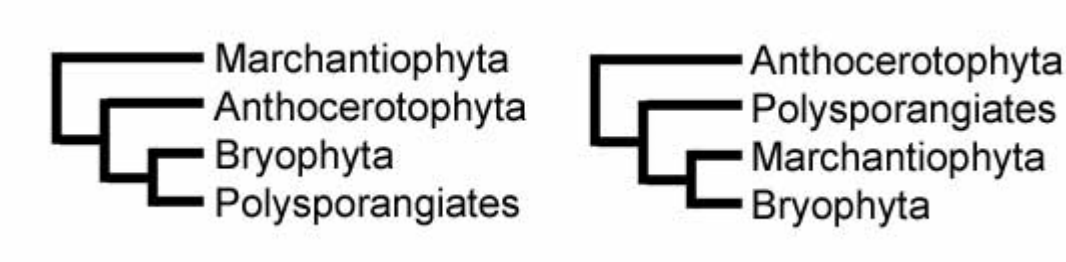
Ecology

Today, liverworts can be found in many ecosystems across the planet except the sea and excessively dry environments, or those exposed to high levels of direct solar radiation. As with most groups of living plants, they are most common (both in numbers and species) in moist tropical areas. Liverworts are more commonly found in moderate to deep shade, though desert species may tolerate direct sunlight and periods of total desiccation.

Classification

Relationship to other plants

Traditionally, the liverworts were grouped together with other bryophytes (mosses and hornworts) in the Division Bryophyta, within which the liverworts made up the class **Hepaticae** (also called Marchantiopsida). However, since this grouping makes the Bryophyta paraphyletic, the liverworts are now usually given their own division. The use of the division name Bryophyta *sensu lato* is still found in the literature, but more frequently the Bryophyta now is used in a restricted sense to include only the mosses.



Two hypotheses on the phylogeny of land plants (embryophyta).

Another reason that liverworts are now classified separately is that they appear to have diverged from all other embryophyte plants near the beginning of their evolution. The strongest line of supporting evidence is that liverworts are the only living group of land plants that do not have stomata on the sporophyte generation. Among the earliest fossils believed to be liverworts are compression fossils of *Pallaviciniites* from the Upper Devonian of New York. These fossils resemble modern species in the Metzgeriales. Another Devonian fossil called *Protosalvinia* also looks like a liverwort, but its relationship to other plants is still uncertain, so it may not belong to the Marchantiophyta. In 2007, the oldest fossils assignable to the liverworts were announced, *Metzgeriothallus sharonae* from the Givetian (Middle Devonian) of New York, USA. However, in 2010, five different types of fossilized liverwort spores were found in Argentina, dating to the much earlier Middle Ordovician, around 470 million years ago.

Internal classification

Bryologists classify liverworts in the division **Marchantiophyta**. This divisional name is based on the name of the most universally recognized liverwort genus *Marchantia*. In addition to this taxon-based name, the liverworts are often called **Hepaticophyta**. This name is derived from their common Latin name as Latin was the language in which botanists published their descriptions of species. This name has led to some confusion, partly because it appears to be a taxon-based name derived from the genus *Hepatica* which is actually a flowering plant of the buttercup family Ranunculaceae. In addition, the name Hepaticophyta is frequently misspelled in textbooks as **Hepatophyta**, which only adds to the confusion.

Although there is no consensus among bryologists as to the classification of liverworts above family rank, the Marchantiophyta may be subdivided into three classes:

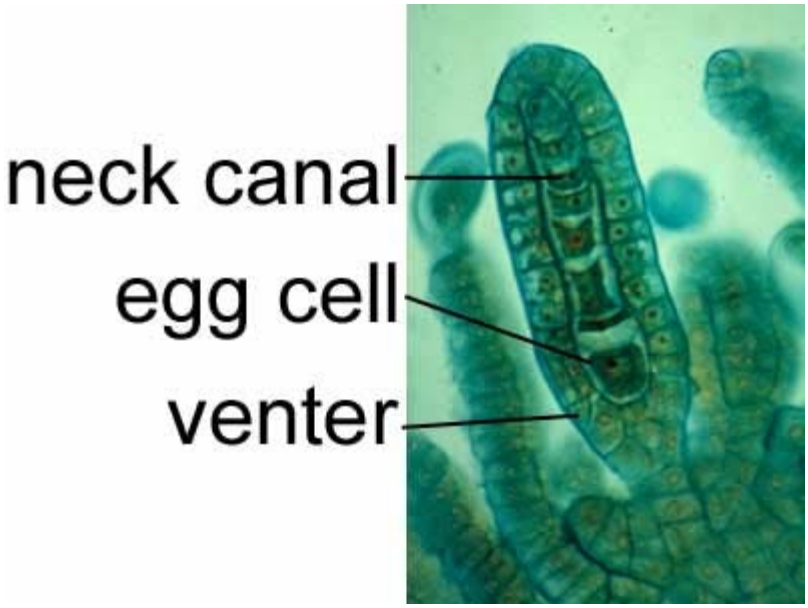
- The **Jungermanniopsida** includes the two orders Metzgeriales (simple thalloids) and Jungermanniales (leafy liverworts).
- The **Marchantiopsida** includes the three orders Marchantiales (complex-thallus liverworts), and Sphaerocarpales (bottle hepatics), as well as the Blasiales (previously placed among the Metzgeriales). It also includes the problematic genus *Monoclea*, which is sometimes placed in its own order Monocleales.
- A third class, the **Haplomitriopsida** is newly recognized as a basal sister group to the other liverworts; it comprises the genera *Haplomitrium*, *Treubia*, and *Apotreubia*.

Economic importance

In ancient times, it was believed that liverworts cured diseases of the liver, hence the name. In Old English, the word liverwort literally means *liver plant*. This probably stemmed from the superficial appearance of some thalloid liverworts (which resemble a liver in outline), and led to the common name of the group as *hepatics*, from the Latin word *hēpaticus* for "belonging to the liver". An unrelated flowering plant, *Hepatica*, is sometimes also referred to as liverwort because it was once also used in treating diseases of the liver. This archaic relationship of plant form to function was based in the "Doctrine of Signatures".

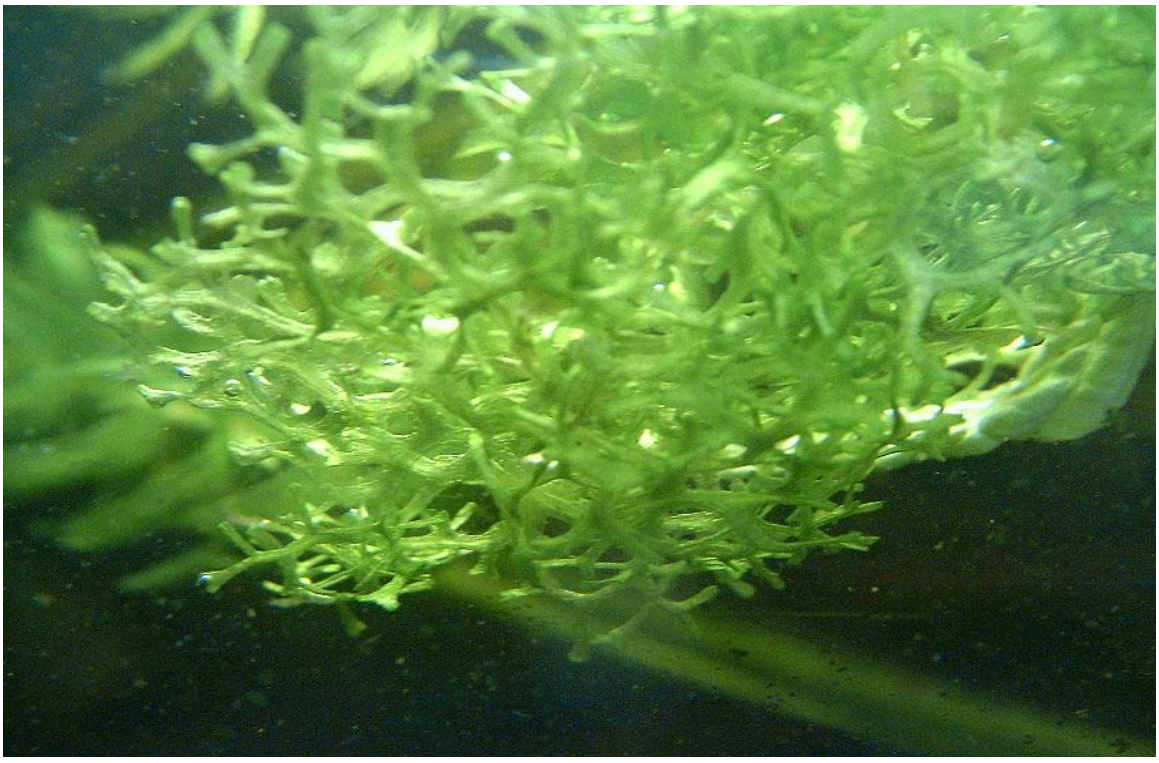
Liverworts have little direct economic importance today. Their greatest impact is indirect, through the reduction of erosion along streambanks, their collection and retention of water in tropical forests, and the formation of soil crusts in deserts and polar regions. However, a few species are used by humans directly. A few species, such as *Riccia fluitans*, are aquatic thallose liverworts sold for use in aquariums. Their thin, slender branches float on the water's surface and provide habitat for both small invertebrates and the fish that feed on them.

Marchantia polymorpha, with antheridial and archegonial stalks



The archegonium of *Porella*

Porella platyphylla clump growing on a tree



Riccia fluitans, an aquatic thallose liverwort

Pellia epiphylla, growing on moist soil

A sporophyte emerging from its archegonium

Plagiochila asplenioides, a leafy liverwort

Conocephalum conicum, a large thallose liverwort

Chapter- 16

Haplomitriopsida and Metzgeriales

Haplomitriopsida

Haplomitriopsida **Temporal range: Early Permian–Recent**
Scientific classification
Kingdom: Plantae
Division: Marchantiophyta
Class: **Haplomitriopsida** Stotler & Stotl.-Crand.
Orders
Haplomitriales Treubiales
Synonyms
Treubiopsida

Haplomitriopsida is a newly recognized class of liverworts comprising fifteen species in three genera. Recent cladistic analyses of nuclear, mitochondrial, and plastid gene sequences place this monophyletic group as the basal sister group to all other liverworts. The group thus provides a unique insight into the early evolution of liverworts in particular and of land plants in general.

Description

Plants of *Treubia* grow as a prostrate leafy thallus. The bifid leaves extend like wings on either side of the midrib, or may be folded upwards and pressed close together, giving the plants a ruffled appearance. By contrast, *Haplomitrium* grows as a subterranean rhizome with erect leafy stems. The thin, rounded leaves are arranged around the upright stems,

giving the appearance of a soft moss. The species *Haplomitrium ovalifolium* of Australia often has bifid leaves that are asymmetrical, somewhat like those in *Treubia*.

Haplomitrium has a number of unique characters that distinguish it from other liverworts, such as lacking rhizoids. The vegetative stems possess a central water-conducting strand with large perforations derived from plasmodesmata. This central strand is surrounded by a cylinder of cells that conduct food throughout the plant. Such an arrangement is evocative of the xylem and phloem found in vascular plants. Although some thalloid liverwort species in the Pallaviciniaceae also possess a central conducting strand, *Haplomitrium* differs in having a food-conducting layer and in producing no callose.

Treubia also has features that differ from those found in other bryophytes, such as the differentiation of five identifiable zones in the stem midrib. Unlike other leafy species, the oil bodies in its cells are restricted to certain clusters of cells, as they are in the Marchantiopsida. These oil body clusters appear as dark spots in the leaves when the plant is held up to the light.

Diversity

Living representatives of the group exhibit an essentially Gondwanan distribution with its center of diversity in Australasia. Such a distribution implies that the modern genera radiated prior to the beginning of the Cretaceous when Gondwana broke apart. Schuster proposes that species distributed in the northern hemisphere "rafted" on the Indian subcontinent to Asia, then spread across the Bering Strait into North America.

Most species in the Haplomitriopsida are found in south of the equator, though there are northern ones. The genus *Treubia* is restricted to the southern hemisphere, while *Apotreubia* has one species in New Guinea and another disjunct between eastern Asia and British Columbia. The genus *Haplomitrium* exhibits a wider distribution, with species in both North and South America, northern and central Europe, the Himalayas, Japan, and Australasia.

Classification

Class Haplomitriopsida includes two orders, each with one family. The group as a whole comprises fifteen species in three genera. A fourth genus, *Gessella*, is known only from Permian fossils. The orders, families, and genera are as follows:

- **Order** Haplomitriales
  - **Family** Haplomitriaceae

    Gessella †
    Haplomitrium (8 species)

- **Order** Treubiales
  - **Family** Treubiaceae

Apotreubia (2 species)
Treubia (6 species)

An additional fossil *Treubiites kidstonii* previously has been compared to the extant genus *Treubia*. However, upon re-examination of the material, specimens were determined to be more like *Blasia* and not at all to resemble *Treubia* as previously thought. Accordingly, *Treubiites* is now assigned to the Blasiales rather than the Haplomitriopsida.

Metzgeriales

Metzgeriales **Temporal range: Upper Devonian to recent**

Riccardia palmata
Scientific classification

Kingdom:	Plantae
Division:	Marchantiophyta
Class:	Jungermanniopsida
Order:	**Metzgeriales** Chalaud, 1930

Families

Allisoniaceae
Aneuraceae
Calyculariaceae
Fossombroniaceae
Hymenophytaceae
Makinoaceae
Metzgeriaceae
Mizutaniaceae
Moerckiaceae
Pallaviciniaceae
Pelliaceae

Petalophyllaceae
Phyllothalliaceae
Sandeothallaceae
† *Metzgeriites*

Synonyms

Anacrogynae (various authors)
Frondosae Endlicher, 1841

Metzgeriales is an order of liverworts. The group is sometimes called the **simple thalloid liverworts**: "thalloid" because the members lack structures resembling stems or leaves, and "simple" because their tissues are thin and relatively undifferentiated. All species in the order have a small gametophyte stage and a smaller, relatively short-lived, spore-bearing stage. Although these plants are almost entirely restricted to regions with high humidity or readily available moisture, the group as a whole is widely distributed, and occurs on every continent except Antarctica.

Description

Members of the Metzgeriales typically are small and thin enough to be translucent, with most of the tissues only a single cell layer in thickness. Because these plants are thin and relatively undifferentiated, with little evidence of distinct tissues, the Metzgeriales are sometimes called the "simple thalloid liverworts".

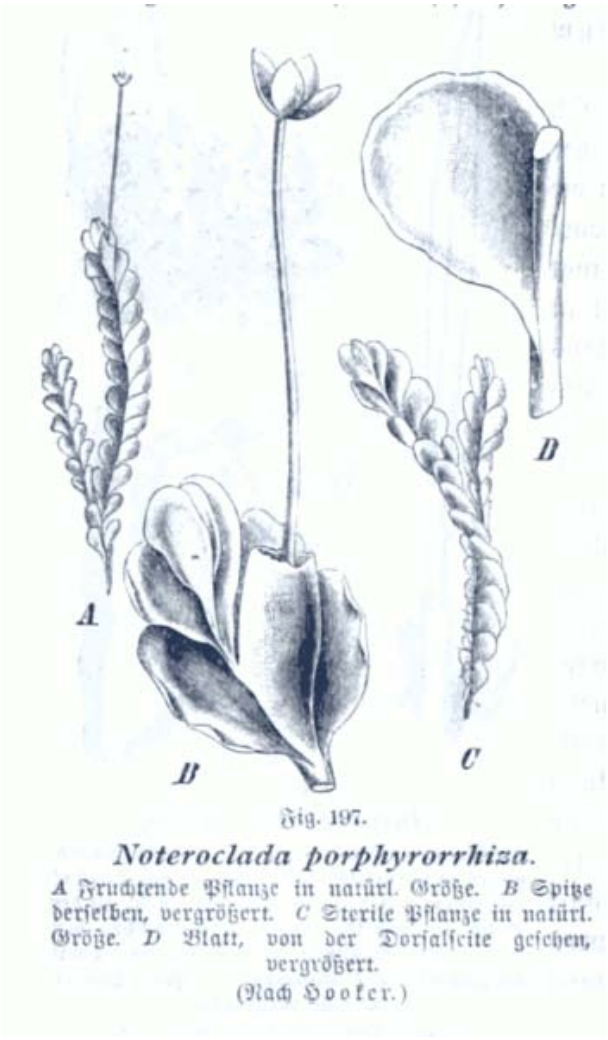


Fig. 197.

Noteroclada porphyrorrhiza.

A Fruchtende Pflanze in natürl. Größe. *B* Spitze derſelben, vergrößert. *C* Sterile Pflanze in natürl. Größe. *D* Blatt, von der Dorſalſeite geſehen, vergrößert.

(Nach Hooker.)

Noteroclada, a "leafy" member of the Metzgeriales

There is considerable diversity in vegetative structure of the Metzgeriales. As a rule, simple thalloid liverworts do not have structures resembling leaves. However, a few genera, such as *Fossombronia*, and *Symphyogyna*, are "semileafy" and have a thallus that is very deeply lobed, thus giving the appearance of leafiness. The genus *Phyllothallia* has a more striking leafiness, with paired lobes of tissue spaced regularly at swollen nodes along a central, forked stem. The several semileafy groups within the Metzgeriales are not closely related to each other, and the currently accepted view is that the leafy condition evolved separately and independently in each of the groups where it occurs.

Members of the Metzgeriales also differ from the related Jungermanniales in the location of their archegonia (female reproductive structures). Whereas archegonia in the Jungermanniales develop directly from the apical cell at the tip of a fertile branch, archegonia in the Metzgeriales develop from a cell that is behind the apical cell. As a result, the female reproductive organs, and the sporophytes that develop within them, are always located on the dorsal surface of the plant. Because these structures do not develop

at the apex of the branch, their development in the Metzgeriales is described as *anacrogynous*, from Greek ἀν- (*an*-, "not") + ἄκρος (*akros*, "tip") + γυνή (*gynē*, "female"). The group was accordingly known as the **Anacrogynae** prior to being recognized as a separate order.

Distribution and ecology

Although these plants are almost entirely restricted to regions with high humidity or readily available moisture, the group as a whole is widely distributed, and occurs on every continent except Antarctica.

One simple thalloid liverwort is not photosynthetic. The species *Cryptothallus mirabilis* is white as a result of lacking chlorophyll, and has plastids that do not differentiate into chloroplasts. This species is a myco-heterotroph that obtains its nutrients from fungi growing among its tissues. These plants grow in bogs and are typically found under peat moss near birch trees.

Classification

The beginning of modern liverwort nomenclature is marked with the 1753 publication of Linnaeus' *Species Plantarum*, although this relied heavily upon the prior work of Micheli (1729) and Dillenius (1741). Linnaeus included all 25 known species of liverworts, together with mosses, algae, and fungi, within a single class Cryptogamia. Linnaeus' system was heavily revised by workers in the early nineteenth century, so that by the time Endlicher published his *Enchiridion Botanicum* in 1841, five orders of liverworts were defined, and the "Frondosae" were segregated as a group that is congruent with the modern concept of the Metzgeriales. Endlicher's "Frondosae" included five subgroups (Metzgerieae, Aneureae, Haplolaeneae, Diplomitrieae, and Codonieae) with no assigned taxonomic rank, but these groups were termed *Familien* by Dědeček in 1886. The same five subgroups of "Frondosae", without significant change, were used in the *Synopsis Hepaticarum* of Gottsche, Lindenberg, and Nees.

A more thorough understanding of the Metzgeriales was not achieved until the morphological and developmental work of Leitgeb in the late nineteenth century. Leitgeb was among the first to recognize and appreciate the significance of development and reproductive morphology as a guide to distinguishing liverwort groups. His careful examinations guided revisions made in the classification published from 1893 to 1895 by Schiffner in Engler and Prantl. Schiffner thus divided his "Jungermanniales" into two broad groups according to whether the archegonia were terminal on reproductive branches (*Jungermanniales akrogynae*) or sub-terminal (*Jungermanniales anakrogynae*). This latter group included what are now recognized as the Metzgeriales, Sphaerocarpales, and Haplomitriales.

The simple thalloids were not given ordinal status until 1930 by Chalaud. Although subsequent systems similarly treated the group as distinct, the name of the order was more often given as "Jungermanniales anacrogynae" (or similar), or the group was

retained within the Jungermanniales as a suborder with either this name or the name "Metzgerineae". The highly influential and comprehensive 1966 classification found in Schuster's *Hepaticae and Anthocerotae of North America* firmly established the name "Metzgeriales" for the group, although he had used this name in his earlier works. Schuster revised his system in 1972 and again in 1984. The only change he made in the circumscription of the Metzgeriales was to remove the Treubiales in accordance with that change made in the classification of Schljakov.

Schljakov's 1972 classification had elevated several subordinal groups within the simple thalloids to the rank of order, and treated the Metzgeriales itself as a superorder "Metzgerianae", but Schuster's 1984 system rejected most of these changes. The classification of Crandall-Stotler and Stotler (2000) adopted several of Schljakov's orders, while revising their membership and grouping them within a subclass "Metzgeriidae". These changes reflected a morphological analysis of species that had been presented three years earlier. Although their system changed the rank and the Latin ending of the name, the composition was identical to the Metzgeriales of Schuster (1966), with only the addition of the Haplomitriales to its membership. Subsequent studies incorporating DNA sequence analysis have removed the Haplomitriales, Treubiales, and Blasiales and place those taxa elsewhere. The remnant of the group, after the removal of these taxa, consists of their Metzgeriales (7 families), Fossombroniales (4 families), and the Phyllothalliaceae.

Families

Pellia epiphylla

The Metzgeriales currently includes fourteen families, as follows:

- Allisoniaceae *
- Aneuraceae
- Calyculariaceae *
- Fossombroniaceae *
- Hymenophytaceae
- Makinoaceae
- Metzgeriaceae
- Mizutaniaceae
- Moerckiaceae
- Pallaviciniaceae
- Pelliaceae *
- Petalophyllaceae *
- Phyllothalliaceae
- Sandeothallaceae *

Families marked with an asterisk * were classified in the separate order Fossombroniales by Crandall-Stotler and Stotler, but this grouping is not supported by subsequent analysis using DNA sequences.

Two additional families were formerly included within the Metzgeriales, but since have been transferred to other classes of liverwort. The Blasiaceae has been assigned its own order Blasiales, and phylogenetic studies show that it is more closely related to the Marchantiales than to members of the Metzgeriales. Likewise, the Treubiaceae is now in its own order Treubiales, within the recently recognized class Haplomitriopsida.

Botanical authority

In previous decades, there has been considerable confusion over the correct attribution of the name "Metzgeriales". The ordinal name Metzgeriales was first published by Chalaud in 1930 with the description “J’ai désigné très généralement les Jungermannniales anacrogynes sous le nom de Metzgériales,” (that is: "I have designated very generally the *Jungermannniales anacrogynes* under the name of *Metzgeriales*"). Chalaud cited Underwood 1894 in support of his treatment, but Underwood himself used only the name *Metzgeriaceae* for the group, and considered the whole to represent a single family. The publication of the ordinal name by Chalaud was accepted as correct by Grolle in his 1983 synopsis of the generic and higher-rank names of liverworts.

Writing in 1984, Rudolf M. Schuster questioned the correct authority for the ordinal name. He believed that Underwood had first used the term, but concluded that as neither Underwood nor Chalaud had provided a formal description, the order should be cited as "Metzgeriales Schust. emend. Schljak." He ascribed first use of the name with a description to his own 1953 work on the liverworts of Minnesota. This work included a considerable description sufficient to distinguish the order from all others, but Schuster relied on the 1972 emendation by Schljakov to provide the Latin diagnosis required by the *International Code of Botanical Nomenclature*. Schuster reaffirmed his position on the authority for publication in 1992.

In the publication of their revised liverwort classification in 2000, Crandall-Stotler and Stotler agreed with Schuster as to the attribution of the name, although they restricted their circumscription of the order considerably. However, upon additional review of the Chalaud paper, they reversed their opinion. They concluded that Chalaud's diagnosis, although "terse", was nonetheless adequate to satisfy the requirements for publication of a

botanical name, and that the *Code*'s requirement for a Latin diagnosis did not apply, since the Chalaud paper was published prior to 1 January 1935. Chalaud is therefore the correct authority in citing the name "Metzgeriales".

Fossil record

Metzgeria furcata

Because plants belonging to the Metgeriales lack hard tissues, and the plants often decay or die back, preservation of fossils is dependent upon rapid burial by floods or volcanic ash. Bryophytes are considered "delicate" plants, and this characteristic is often cited as the reason for the apparently poor fossil record of the group. However, fossils of the Metzgeriales are distributed widely, both geographically and stratigraphically, and the fossils which have been found are often highly detailed and well-preserved.

The oldest fossil bryophyte is a compression fossil of *Pallavicinites devonicus* from Upper Devonian rocks that has been confidently assigned to the Metzgeriales. Portions of the fossil that have been isolated for microscopic examination reveal an extraordinary degree of cellular detail. The plant consisted of a thin, ribbon-like, bifurcating thallus with a thicker central midrib. The plant is remarkably similar in structure to members of the extant liverwort family Pallaviciniaceae, but no reproductive structures have been found. Additional species assigned to the genus *Pallavicinites* have been found in rocks dating from the Carboniferous to the Pleistocene.

Another early fossil probably belonging to the Metzgeriales is the Carboniferous fossil *Thallites willsi*, which has been compared to the modern genus *Metzgeria*. However, it has been assigned to the form genus *Thallites*, which is used for thalloid fossil plants and algae of uncertain relationships. Most fossils belonging to the Metzgeriales are assigned to the genus *Metzgeriites*, which was established for this purpose. Specimens from the Upper Carboniferous of Shropshire, England, have been named *Hepaticites metzgerioides*, and (as the specific epithet indicates) these specimens strongly resemble the genus *Metzgeria*. However, they have been placed instead in the form genus *Hepaticites*, used for fossils believed to be liverworts but without confident affiliation with any extant order. This species is not restricted to British localities, but has also been found in the Karagandy Province of Kazakhstan.

Mesozoic fossils of *Metzgeriites* have also been found. *Metzgeriites glebosus* has been collected from Jurassic strata of Greenland. The type material, and so far only material collected, consists of a midrib with a thin lamina that is deeply and irregularly lobed. A Cretaceous fossil from Portugal has been named *Metzgeriites infracretaceus*. Like *M. glebosus*, it possesses a midrib and thin lamina, but unlike that taxon the lamina of *M. infracretaceus* is not lobed.

Chapter- 17

Colura Zoophaga and Marchantia Polymorpha

Colura zoophaga

Colura zoophaga	
Scientific classification	
Kingdom:	Plantae
Division:	Marchantiophyta
Class:	Jungermanniopsida
Order:	Jungermanniales
Family:	Lejeuneaceae
Genus:	*Colura*
Species:	***C. zoophaga***
Binomial name	
Colura zoophaga E.Fischer	

Colura zoophaga is a species of epiphytic liverwort that is endemic to the African highlands, specifically parts of Kenya. It belongs to the genus *Colura*, which has been hypothesized to be have carnivorous attributes as early as 1893. It is a recently described species that was the subject of the first scientific study aimed at investigating the allegations of carnivory in liverworts.

Description

Colura zoophaga is a small epiphytic liverwort that measures no more than several millimetres in size and grows on the trunk and branches of *Cliffortia nitida*. It possesses elongated water sacs formed by the fusion of the upper leaf margin rolling inward down to the rest of the leaf. A funnel-shaped channel at the lower leaf margin leads to a small opening into the water sac and is covered by a movable lid that only open inward. Leaves

are 1 mm long or smaller. It is because of this bladder-like configuration that these traps have been compared to those of *Utricularia*.

Carnivory

The habitat of *Colura zoophaga*, epiphytic and deriving all nutrients from rainwater, has been compared to that of known carnivorous plants such as *Brocchinia reducta*, an epiphytic bromeliad. The carnivorous habit typically evolves in genera and species that are located in nutrient-poor habitats, but are very moist. In that way, this species of liverwort at least fits the profile for a carnivorous plant.

The traps have been described as early as 1893 by Karl von Goebel. Other botanists, such as Kerner von Marilaun, also noted the trap structure and described how prey were captured in other members of the genus. *Colura zoophaga* was chosen as a subject for study in an investigation into the claims of liverwort carnivory. Wilhelm Barthlott and his colleagues noticed that ciliates were grazing the surface of the leaves for bacteria. In the lab they introduced *Blepharisma americana* and observed them also grazing for bacteria in the funnel-shaped channel, pressing on the one-way door. The ciliate's behavior resulted in them getting trapped in the water sac, eventually dying and bursting, releasing their contents.

It has not been determined, however, if and how *Colura zoophaga* attracts its prey or if it produces proteases or other digestive enzymes to break down the prey. Barthlott *et al.* suggested that it may be reasonable to assume it doesn't produce such enzymes and that, like some other species of carnivorous plants (e.g. some *Heliamphora* species), it may rely on commensals such as bacteria to break down the prey. There has been no experimental evidence of this, nor has there been evidence of absorption of the prey by the traps. These are typically the criteria by which other carnivorous plants have been identified.

Marchantia polymorpha

Marchantia polymorpha

Scientific classification
Kingdom: Plantae
Division: Marchantiophyta
Class: Marchantiopsida
Order: Marchantiales
Family: Marchantiaceae
Genus: *Marchantia*
Species: ***M. polymorpha***
Binomial name
Marchantia polymorpha L.
Synonyms
Marchantia alpestris *Marchantia aquatica*

Marchantia polymorpha, sometimes known as the **common liverwort** or **umbrella liverwort**, is a large liverwort with a wide distribution around the world. It is variable in appearance and has several subspecies. It is dioecious, having separate male and female plants.

Description

It is a thallose liverwort which forms a rosette of flattened thalli with forked branches. The thalli grow up to 10 cm long with a width of up to 2 cm. It is usually green in colour but older plants can become brown or purplish. The upper surface has a pattern of hexagonal markings. The underside is covered by many root-like rhizoids which attach the plant to the soil. The plants produce umbrella-like reproductive structures known as gametophores. The gametophores of female plants consist of a stalk with star-like rays at

the top. These contain archegonia, the organs which produce the ova. Male gametophores are topped by a flattened disc containing the antheridia which produce sperm.

Reproduction

Marchantia polymorpha can reproduce both sexually and asexually. Sexual reproduction involves sperm from the male plant fertilizing ova from the female plants. A fertilized ovum develops into a small sporophyte plant which remains attached to the larger gametophyte plant. The sporophyte produces male and female spores which develop into free-living gametophyte plants.

Asexual reproduction can occur when older parts of the plant die and newer branches develop into separate plants. It can also occur by means of gemmae, balls of cells which are genetically identical to the parent and contained in cup-like structures on the upper surface of the plant. These are dispersed when rain splashes the cups and develop into new plants.

Distribution and habitat

It is found worldwide from tropical to arctic climates. It grows on moist soil and rocks in damp habitats such as the banks of streams and pools, bogs, fens and dune slacks. It rapidly colonizes burnt ground after fires. It often grows in man-made habitats such as gardens, paths and greenhouses and can be a horticultural weed.